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Nest Success in a Grassland Bird Community: Microsite Selection & a Case for Nest Height Manipulation

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ABSTRACT

Grassland birds are a sensitive community and populations around the country have been declining. They are susceptible to low nest success due to loss of habitat and the small, fragmented patches that remain are often subjected to elevated levels of nest predation. The American goldfinch (*Spinus tristis*), which uses grasslands for feeding and nesting, is understudied given its abundance, due in part to its late-season nesting habits, and selection of taller woody vegetation as nesting substrate, which is atypical for many grassland nesting birds. American goldfinches were incorporated in this study which included nest height manipulation of goldfinch nests, to determine the effect of this variable on predation pressures for the east-central Illinois grassland bird community in Coles County, IL. Overall nest success for the grassland bird community was high (48.6%) and American goldfinch nest success was the highest of all species (58.18%).

Manipulation of nest height resulted in fewer raised nests being predated than both control and lowered nests, and significant changes in nest concealment occurred due to moving a nest either up or down the nesting substrate. The incorporation of the American goldfinch in grassland research may lend insight to whether nest height placement affects survival, rather than other nest site characteristics. Nest height manipulation is a novel way of potentially testing the importance of nest height for future survival projects.

Acknowledgements

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Introduction & Literature Review

The grassland biome in the United States has become increasingly fragmented and reduced due to agriculture and degradation (Herkert 2003), with only a small percentage of the historic grassland area remaining today (Samson & Knopf 1994; Peterjohn and Sauer 1999; Green et al. 2005). Expansive prairies have been converted to agriculture, and a lapse in management practices can result in the landscape reverting to early successional forest. This has led to a decrease in grassland bird populations (Bollinger et al. 1990; Peterjohn and Sauer 1999; Green et al. 2005), since some species are considered grassland obligates and require the biome for reproduction.

Throughout the central United States, fragmentation has led to smaller areas of grassland habitat and increased negative edge-effects that can leave birds susceptible to nest predators and brown-headed cowbird (*Molothrus ater*) parasitism (Lahti 2001). The decrease of grassland area, coupled with the presence of predators can lead to easier detection by predators due to smaller search areas, and increased chances of detecting a nest incidentally while traveling. This loss of cover type coupled with smaller patches can cause remaining fragments to have low avian reproductive productivity that could cause these small patches to be considered ecological traps (Shochat et al. 2005; Henningsen and Best 2005; Jaster et al. 2014,).

The array of predators in grasslands can greatly affect the success of grassland birds, including ground squirrels (Dion et al. 2000; Klug et al. 2009), snakes (Davison and Bollinger 2000), foxes and raccoons (Patterson and Best 1996). Raccoons (*Procyon lotor*) are a common omnivore in Illinois that eat nest contents, more often with ground nests than nests in shrubs (Schmidt and Whelan 1999). While they may move quickly

through grasslands and may not actively search for nests, incidental encounters can lead to predation (Newbury and Nelson 2007). The same may be true for skunks (*Mephitis mephitis*) (Vickery et al. 1992), and white-tailed deer (*Odocoileus virginianus*) have come into focus as a possible nest predator, as they have been recorded eating nest contents (Pietz and Granfors 2000; Murray 2015). Snakes are considered the primary source for nest predation in grasslands (Klug et al. 2010) and mesopredators can detect a nest by chance and predate the contents (Vickery et al. 1992; Newbury and Nelson 2007).

Since grassland nesting birds build nests at different heights, this may leave them susceptible to different predation pressures. As many as thirty bird species will utilize grassland cover for food and nesting purposes. Some of these species are considered grassland obligates, but many species associated with edges, and many generalist species use grasslands as well. One generalist species that uses grasslands and fields for nesting and food is the American goldfinch (*Spinus tristis*).

The American goldfinch can be found in a variety of habitats, including CRP grasslands (McCoy et al. 1999), state managed grasslands (Fletcher, Jr. and Koford 2002), but also in woodland and shrub habitats (Schmidt 2003), and urban or developed areas and riparian forests (Dybala et al. 2014). The goldfinch has a unique nesting habit and diet that differs from most other songbirds. They are late nesters, most typically initiating first nests in mid-July (Middleton 1977), when most other songbirds are finishing their nesting cycles. This is due to the late bloom of fibrous flowers such as thistle and asters that goldfinches rely on for nest material and food (Middleton 1977; Middleton 1991; Furlonger et al. 2012). Unlike most grassland songbirds, goldfinches place nests in the joints of tall shrubs, trees, and forbs (Middleton 1993), while it is

widely known that birds that are grassland obligates nest on or close to the ground. This nesting strategy has led to high nest success in areas where ground-nesting birds have been highly affected by nest predation (McCoy et al. 1999; Schwenk and Donovan 2011).

Although the goldfinch is extremely abundant with an increasing population trend (BirdLife International 2012) and an estimated total population of 42 million (Partners in Flight 2012), the amount of field research on the species is rather small. They are sometimes briefly mentioned with few recorded nests in grassland bird-related literature or are excluded due to their late-season breeding habits (Schmidt 2003). The goldfinch has been documented in some grasslands showing positive population trends and a preference toward protected grasslands (Herkert 2009). McCoy et al. (1999) found relatively fewer goldfinch nests compared to grassland obligate birds like the grasshopper sparrow (*Ammodramus* savannarum) and dickcissel (*Spiza americana*) in Missouri but found nest success as high as 70%. Schwenk and Donovan (2011) included the goldfinch in a guild of birds that favored edges and open areas and showed an overall increase in abundance near edge habitat and a lower abundance with increased percent forest cover. Since American Goldfinches are affected by the same predator suite, it is important to include them in studies pertaining to survival focused on a grassland bird community. The study of the entire suite of grassland nesting birds is imperative to documenting the results of grassland management and the current fragmentation issue. Since the cover type is becoming increasingly rare, it is important to learn which species are benefiting from management and conservation of remaining plots.

A novel experimentation method that has not been detected through literature review is the manipulation of nest height of naturally occurring nests. While Jarvinen et

al. (2017) manipulated nest height of blue tits, this was done within confined nest boxes. Rounds et al. (2004) used potential nest site manipulation by raising shellpiles for terns and oystercatchers in Virginia. There is research pertaining to nest site manipulation. Holcomb (1971) manipulated the integrity of red-winged blackbird nests during the build and early incubation stages but did not change nest height. Howlett & Stutchbury (1996) removed vegetation around hooded warbler nests during incubation to test effects of concealment. Other studies like Remes (2005) investigated nest concealment by manipulating nest site vegetation through cutting, which was also done by Peak (2003) in east-central Illinois on American goldfinch nests.

In this study. nest height manipulation was performed on active American goldfinch nests to determine if their nesting strategy in tall trees, with nest placement much higher than most other birds, carries a competitive advantage when compared to the avian community. Nest height manipulation can be a useful tool to introduce new predation pressures by changing susceptibility to predation. Since many grassland nesters chose locations very close to the ground, their nests cannot be easily manipulated. However, a shrub or tree nest could be manipulated, which is the focus of this study. This can help determine if nest height is a significant predictor of nest success, as birds may rely on different vegetation characteristics of the nest microsite relative to nest height. This may also determine any differences in predation pressure due to the initially taller height of American goldfinch nests compared to other grassland-nesting birds and may allow us to see if height manipulation either introduces or excludes predators from detecting and depredating nests.

The objectives of this study were to determine nest success of the entire grassland bird community, determine vegetation characteristics that birds are selecting as they choose a nest site, and to see how those decisions may affect nest success. By incorporating American goldfinch nest data with grassland obligate and edge-nesting birds, there may be insight to whether goldfinches have higher nesting success due to their nest height or location. This could lead to management suggestions that make grasslands more attractive for particular species and lead to increased reproductive success for a community that suffers high nest predation.

Methods

Study Sites

Four regional properties surrounding Charleston, IL were used for this study (Figures 1 & 2). Douglas-Hart Nature Center (Figure 3) in Mattoon, IL, Coles County, was used in 2015, but not 2016 because only two nests were detected in 2015. About half of the 26 ha property was managed for native prairie whereas the other half was forested. There was a small forested wetland and a pond in the prairie area. The other three sites, managed by the Illinois Department of Natural Resources, were used in both 2015 and 2016. The Paul C. Burrus Habitat Area (Figure 4) encompassed 160 ha, and was located south of Hutton, IL in Coles County. This large property had four accessible prairie plots that were denoted for this study as northwest, northeast, southeast, and southwest. These plots comprised approximately 35 ha of grasses, native prairie forbs, and berry bushes (*Rubus* spp.). The Larry D. Closson Habitat Area (Figure 5) and Hindsboro Pheasant Habitat Area (Figure 6), both near Hindsboro, IL in Douglas County were the other two sites. Closson had four quadrants totaling 55 ha; the southeast, approximately 12 ha, was

a redtop grass (*Argostis gigantean*) field mixed with brome (*Bromus spp.*), Canada thistle (*Cirsium arvense*), and clover (*Trifolium spp*.). The southwest quadrant, approximately 10 ha, was a brome/alfalfa (*Medicado sativa*) field mixed with prominent invading thistle (*Cirsium* spp.) and Canada goldenrod (*Solidago canadensis*) stands. The north half of the property consisted of two native prairie plantings. The middle third of the 15 ha northwest quadrant was a restored wetland pond surrounded by native prairie plantings to the north and south. The northeast quadrant, approximately 15 ha, had a 5 ha savannah, a native prairie plot to the north, and a small 1 ha oldfield plot to the south with native prairie plants. Dogwood (*Cornus spp*.), plumb (*Prunus americana),* chokeberry (*Aronia spp*.) and other shrubs and trees were planted on the perimeter of most of the property and bordered the divide between the southeast and southwest quadrants. Due to the stark differences in vegetation at Closson, each quadrant was treated individually for this study. Hindsboro was 36 ha, predominantly native prairie, and was not differentiated by its northeast and southwest sections. A mostly inaccessible tree dominated marsh was in the southwest section, and a switchgrass planting and honey locust (*Gleditsia triacanthos*) encroachment were present in the northeast section.

Nest Searching

Nest searches for all species began in late April and continued through mid-July. Focus shifted to primarily American goldfinches for the remainder of July as most birds had completed nesting and goldfinches were beginning to build nests. Strictly American goldfinch nests were sought in August and September, although virtually no other species were nesting at this time. Searches were conducted using a 1.2 m wooden pole with a diameter of approximately 2 cm.

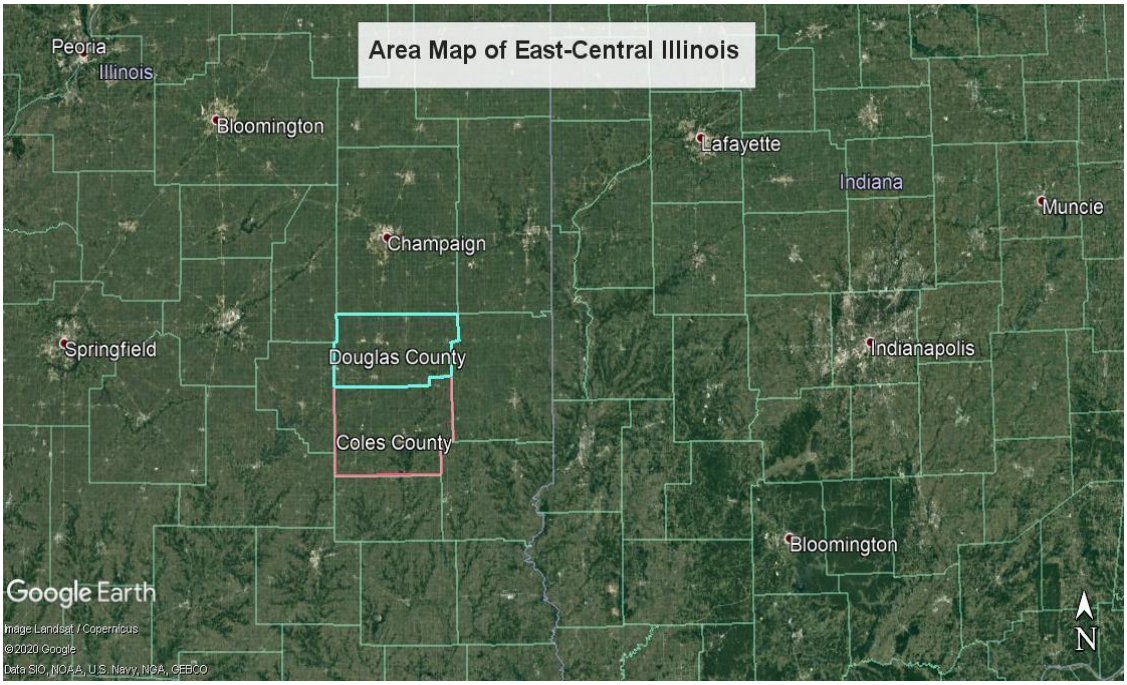

Figure 1. Regional map of Illinois with study counties highlighted.

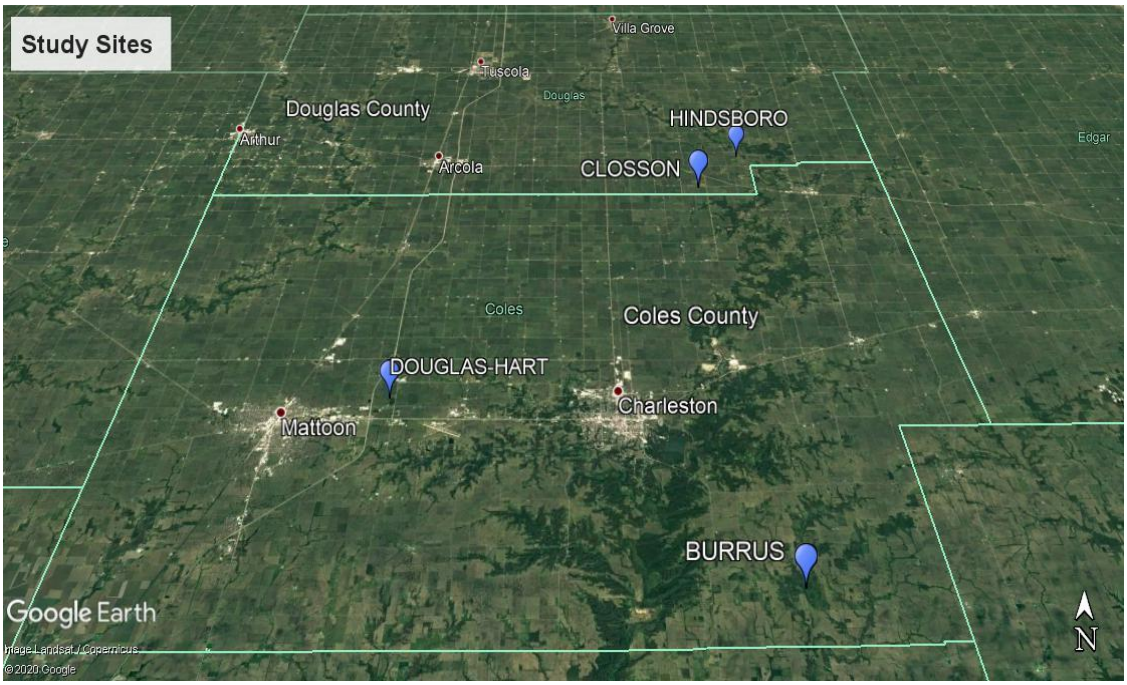

Figure 2. Study sites and their respective locations near Charleston, IL. Study sites are marked with a blue pin.

Figure 3. Map of Douglas-Hart Nature Center Property.

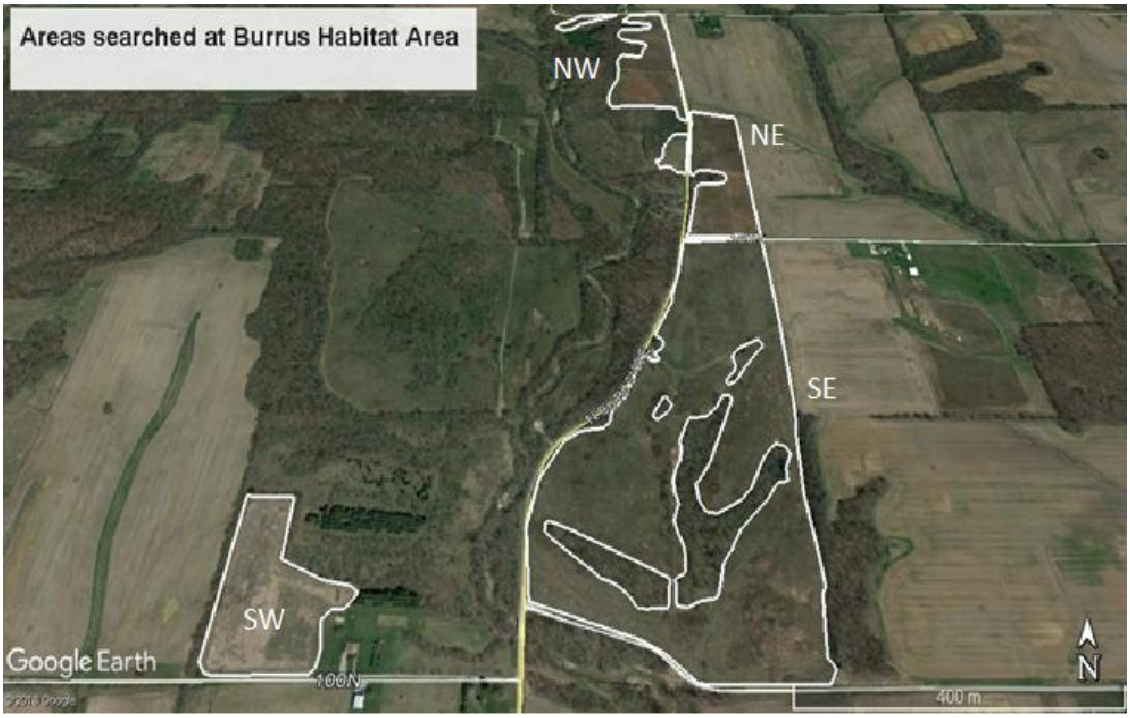

Figure 4. Map of Burrus Habitat Area. Outlined areas and plot names (NW, NE, SE, SW) denote plots used during research.

Figure 5. Google Earth image of Closson Habitat Area, courtesy of https://www.dnr.illinois.gov/hunting/FactSheets/Documents/LarryClossonHunterMap.pdf.

Figure 6. Map of Hindsboro Pheasant Area, Hindsboro, IL.

The pole was waved back and forth over the vegetation to flush birds from nest sites. Once a potential nest-sitting bird flushed, a nest search began. The vegetation was carefully parted with the stick, and sometimes with a hand. Once a nest was discovered, the area was quickly exited after noting the contents, nest height, substrate type that the nest was attached to, and taking an accurate GPS point. The time was recorded in most cases, and the distance of the bird's flush to my position to the closest 0.5 m was estimated and the agitation level of each adult was noted. While rare, a flush beyond 5m was given a 5.5 m distance. Agitation level was given a value between 0-5 depending on the amount of vocalization and mobbing behavior that was exhibited (Table 1). To ensure no dead-end trails which could be noticed by potential predators, I continued walking in the same direction I had been, only turning at least 3m beyond to look for vegetation to flag so I could relocate the nest.

Table 1. Aggression level descriptions for adult birds at nests during nest discovery and nest checks.

Aggression Level	Behavior
0	Bird not present
1	Bird flushes with no vocalization, or bird present with no vocalization
2	Very few distress calls from present adult
3	Moderate amount of distress calls from present adult
4	Non-stop distress calls from present adult
5	Non-stop distress calls from present adult with hovering, diving, or physical contact

Flagging tape was attached to vegetation 3-5 m from the nest. The distance between the nest and flag was estimated and the direction from the flag to the nest was taken with a compass. Nests were sometimes found while walking between active nests during nest checks or during vegetation surveys. Each site had two scheduled searches

outside the American goldfinch nesting season. Trees and woody borders were searched for goldfinch nests more frequently because goldfinches were the only species studied that nested in trees late in the breeding season, and these areas were easy to target.

Nest Checks

Nests were checked between one and seven days apart to reduce uncertainty with nest fate, to accommodate my availability and to make sure I did not trample a nest site with too many visits. Caution was taken to not disrupt the nest site during the same stage, and checks were also timed to expected changes in nest stage, especially close to fledging. This required daily checks for 2-3 days to have a precise fledge day if the nest succeeded, and to aid in determining late nestling stage predation.

A nest was approached from a different angle for each visit, so it was less likely to leave a single path to a nest. I approached as close as necessary to move back any obstructing vegetation with the flushing stick and recorded any flushing from either adult, any aggressive behavior from the adults, and the nest contents. Once the check was complete, I continued along my path until a few meters from the nest and then continued to the next location. Since some goldfinch nests were too high to view, a small mirror was glued to a prescription bottle (Figure 7). The bottom of the bottle was cut out so the stick could be inserted into the bottle. This allowed for accurate nest content viewing from a distance.

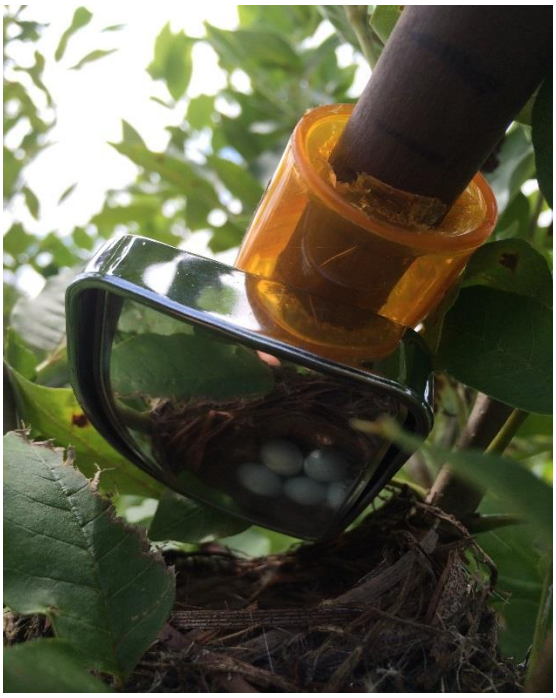

Figure 7. Device created to assist in nest checks for high nests.

Nest Vegetation Surveys

Once a nest succeeded or failed due to predation, abandonment, or weather, a nest site vegetation survey was performed with a Robel pole (Robel et al. 1970) and a Daubenmire frame (Daubenmire 1959). The Robel pole was made from 6 cm diameter PVC and was 2 m long. The Daubenmire frame was 20 cm X 50 cm and made from four 2 cm diameter PVC. The nest height was recorded with the flushing stick at the top of the nest cup, as was the height of the dominant substrate that the nest was built in. Any secondary substrate that a nest was attached to was also recorded. The Robel pole was placed directly on the nest or directly next to the nest and the visual obstruction was read from 1m off the ground and 4 m from the pole in the four cardinal directions. The pole was divided into 10 cm increments numbered 1-20, and the lowest numbered section that

was visible was recorded. The four values were averaged for an estimate of the overall obstruction surrounding the nest. Any value above 2 m was estimated.

The Daubenmire frame was placed over the nest in a north-south orientation and the cover classes of the following were determined, both 'with' and 'without obstruction' from other cover types: bare ground, litter layer, forbs, grass, woody vegetation, and standing dead vegetation. These were recorded in increments of percent cover, using a midpoint for simplicity: 0-5%, midpoint 2.5%; 5-25%, midpoint 15%; 25-50%, midpoint 37.5%; 50-75%, midpoint 62.5%; 75-95%, midpoint 85%; and 95-100%, midpoint 97.5%. 'With obstruction' meant the values of the six categories would equal approximately 100%, whereas 'without obstruction' measured each vegetation category independent of the other five. The average height of live and standing dead vegetation was estimated within the frame. Litter depth was recorded in the four corners of the frame and the values were averaged for a single number. The same process was performed at a randomly selected site between 1 m and 5 m from the nest in a random direction (0-359 degrees) as determined by a random number generator.

Fixed Point Vegetation Surveys

Vegetation surveys with a Daubenmire frame and Robel pole were completed at fixed points within each field about every two weeks (2015 Range = 11-23 days, average = 15 days, 2016 range = 12-17 days, average = 14.2 days). The purpose was to track the growth of vegetation throughout the season. The points were roughly 75 m from one another in each direction. Since boundary shape was variable, properties had varying numbers of points. Douglas-Hart Nature Center had 20 in 2015. Points were added in 2016 at Hindsboro and Closson to better represent variations that were discovered well

into the growing season. Hindsboro had 38 in 2015 to 45 in 2016. Closson had 68 in 2015 and 82 in 2016. Due to a late start on surveys in 2015 and an intense focus on nest searching, the southeast portion of Burrus was omitted in 2015. By the first attempt in mid-June of 2015 the vegetation was very tall and established, and I opted to not destroy the native plants and continued to focus on nest searches. An earlier start in 2016 and a better understanding of the plot's vegetative composition allowed for all four plots to be sampled. Burrus had 25 points in 2015 and 56 in 2016 mainly due to the addition of the large southeast plot. In 2015 the surveys began on 14 June and ended on 6 September. This allowed for 6 intervals of measurements. In 2016 they began on 16 May and went as late as 20 September. Nine sampling intervals were completed at Hindsboro and Burrus, and a tenth round was done at Closson.

Trail Cameras

Trail cameras were deployed to record predation events, to capture daily animal activity in the fields, and to aid in nest species identification. The cameras were attached to wooden stakes with bungee cords and a screw for the base of the camera to rest. A Wildgame Innovations Model # 16, Primos Hunting Easy Cam Model # 63051 and Primos Hunting Work Horse Model # 63310 were used. Cameras were set for continuous capture at the shortest interval the cameras could provide. In some cases, video mode was used. Cameras were placed about 2 m from a nest to capture activity and potential predation events. The cameras were most often deployed along field edges or known game trails to capture local wildlife that could account for nest predation.

Nest Height Manipulation

American goldfinch nest height manipulation was planned for moving two thirds of the total nests that were found. Nests were either left at their original height or placed in a 'low' and 'high' group. Since some nests were too high to reach, they were placed in the control group. This could have led to a bias in my designation of nests in each group, since the order of nest designation was control-low-high. The next reachable nest was then placed in the group that the unreachable nest would have gone in. To account for this potential bias, I stayed at a control nest for approximately the same amount of time it would take to perform a height manipulation. This process would last most often between 5-7 minutes. In case a would-be manipulated nest failed, the next discovered nest was placed into that same group. Nests were carefully snipped from their substrate connections with a pair of scissors (Figure 8) and were reattached at the next highest or lowest suitable nest site on the same substrate. A suitable nest site was determined as a branch joint from the stem or trunk. Reattachment involved sliding zip ties through the nest and fastening them around a branch or trunk at 2-3 locations, mimicking the original attachment points (Figures 9-10). In some cases, a connection of two or three zip ties was fastened under the nest, so the base of the nest sat on the center of the connection for support (Figure 11). The original and manipulated heights of the nests were recorded at the top of the nest cup, and the change in height was recorded. Nest concealment was determined prior to manipulating the height of the nest, and again after the nest succeeded or failed. An average nest height and concealment were calculated using the number of days pre- and post-manipulation and the value during each time period.

Figure 8. American goldfinch nest post-removal from initial placement with nestlings.

Figure 9. Example of reattached nest in fragrant sumac (*Rhus aromatic*a).

Figure 10. Example of reattached American goldfinch nest.

Figure 11. Example of multiple zip tie connection base that was under the nest for additional support, if necessary.

Data Analysis

The Mayfield formula (Mayfield 1961, 1975) was used for nest success for every species. This technique estimates the daily survival rate (DSR), or what percent of nests survive each day when accounting for exposure days after a nest had been discovered. The number of failed nests was divided by the total exposure days to get a failed nests/day value. This was subtracted from 1 to get the final DSR. By raising the DSR to the power of the nesting period (days from lay to fledge, (Birds of the World, The Cornell Lab of Ornithology)) the value becomes the probability of a nest surviving the entire nesting period from day one of egg laying through fledging. If a nest failed or fledged between two visits, the midpoint date between the two was used as the event date. If my presence forced nestlings to fledge, that date was used as the last day checked. Since nests that were close to fledging were sometimes empty during the following visit, it was imperative to gently search the area for nestlings, agitated adults, or adults with food. This provided further evidence that a nest had fledged. The nest was also checked for feces and damage, in case a predator took the near-fledged nestlings. This analysis was only performed for nests with confirmed fates, and nests with very good evidence of fates due to nearby host behavioral cues or by seeing fledglings. Using the approximate length of each species' nest stage and during what stage a nest failed, DSR and survival probability were determined for the laying, incubation, and nestling stages.

The Mayfield formula was also implemented for all American goldfinch nests regardless of treatment. If a nest was moved, a Mayfield analysis was performed for the entire nesting period and for the manipulated time period. If a nest was left as a control,

Mayfield analysis was performed for the entire period, and from the time the simulated manipulation took place.

All data analyses were performed in R studio (R Core Team (2019)). The significance level for tests was $p = 0.05$ unless otherwise stated due to cases of multiple comparisons. Pearson correlation was used on nest site data to find relationships among vegetative characteristics and relationships between vegetation and nest height and determined the statistical significance of these relationships. Paired Student's t-tests were used to test for significant differences between nest sites and random sites, successful and failed nest site characteristics, and to determine if the 'with' and 'without' obstruction vegetation data were significantly different for vegetation cover. Multiple regression models for red-winged blackbirds, dickcissels and American goldfinch were used to determine vegetation characteristics that significantly predicted nest height. Backward and forward modeling determined the simplest models by removing characteristics that were least significant based on AIC values. This would aid in determining which characteristics may universally increase or decrease a species' nest height. Principal components analysis (PCA) determined significant microsite correlations based on nest height, and ordination plots mapped microsite characteristics on a two-dimensional plane. Components with an Eigenvalue larger than 1 were used, and the 13 characteristics of the PCA were correlated to nest height to further represent visual relationships between nest microsite and nest placement. A Bonferroni correction was used due to the multiple comparisons (Dunn, 1961). Logistic regression using a binary (0/1) response for nest fate (failed/success) was performed to determine significant vegetation characteristics, adult agitation, or nest initiation date that led to increased or decreased nest survival. By

knowing the average laying, incubation, and nestling periods for these species, I estimated the day the first egg should have been laid. Since the breeding season typically begins in late April, I used May 1st as day 0, as only 2 nests were presumed to have started prior to that day. I used July 1st as day 0 for the American goldfinch, since they are late nesters. Analysis of Variance (ANOVA) tests were performed to understand differences between nest heights for manipulated goldfinch nests, and to compare inter-species variation of nest characteristics and adult responses. For bi-weekly vegetation surveys, repeated measures ANOVA (RMANOVA) was performed using the time intervals as the independent variable, and the vegetation properties as the dependent variables. This tracked significant changes in cover classes, heights, obstruction and litter depth between the successive surveys.

Results

Between both seasons, 251 active nests were discovered and monitored (Table 2). An additional 61 nests were discovered and monitored with no signs of activity, and visitation ceased after a few nest checks (average number of checks = 3.15). I discovered 91 red-winged blackbird (RWBL) nests and 88 were monitored until fledging or failure. Fifty-five American goldfinch (AMGO), 46 dickcissel (DICK), 19 field sparrow (FISP), 12 common yellowthroat (COYE), and nine American robin (AMRO) nests accounted for most of the remaining nests. Other species whose nests were monitored in low numbers were indigo bunting (INBU), brown thrasher (BRTH), mourning dove (MODO), eastern towhee (EATO), song sparrow (SOSP), eastern kingbird (EAKI), ring-necked pheasant (RNEP), mallard (MALL), eastern meadowlark (EAME), northern bobwhite (NOBO), and Henslow's sparrow (HESP).

Douglas-Hart Nature Center yielded a common yellowthroat and an American goldfinch nest in 2015 and was dropped from monitoring in 2016. Most nests were discovered at Closson (186 nests, 2015 = 61, 2016 = 125) followed by Burrus (33 nests, 2015 = 11, 2016 = 22) and Hindsboro (33 nests, 2015 = 17, 2016 = 16). Burrus nests were predominantly American goldfinch (9), field sparrow (9), and common yellowthroat (7). The majority of Hindsboro nests were American goldfinch (11), field sparrow (9), or dickcissel (6). Closson was dominated by red-winged blackbird nests (89), followed by American goldfinch (37), dickcissel (34) and American robin (9).

Species Survival

Of the 251 monitored nests, 122 (48.6%) were believed to have survived to fledging: (Tables 3 & 4). If a species did not lose a nest, it was not included because DSR and survival probability would both be 1.00 or 100%. The fates of nests were determined by a combination of the stage and/or development of the nest contents at the last nest check, adult behavior, noting new paths, nest integrity, and fledgling sightings.

Table 2. The total number of nests found, by species, at each study site during the 2015 and 2016 field seasons.

Species	Total	2015 Total	DHNC	Burrus	Hindsboro	Closson	2016 Total	Burrus	Hindsboro	Closson
RWBL	91	27	0	0	0	27	64	2	0	62
AMGO	55	25	1	6	7	11	30	3	4	23
DICK	46	23	0	0	3	20	23	3	3	17
FISP	19	5	0	2	3	0	14	7	6	1
COYE	12	4	1	3	0	0	8	4	1	3
AMRO	9	0	0	0	0	0	9	0	0	9
INBU	4	4	0	0	3	1	0	0	0	0
BRTH	3	1	0	0	0	1	2	0	0	2
MODO	3	0	0	0	0	0	3	0	0	3
EAKI	2	1	0	0	0	1	1	0	0	1
EATO	2	0	0	0	0	0	2	1	0	1
RNEP	2	0	0	0	0	0	2	1	1	0
SOSP	2	0	0	0	0	0	2	0	1	1
EAME	1	0	0	0	0	0	1	0	0	1
HESP	1	1	0	0	1	0	0	0	0	0
MALL	1	0	0	0	0	0	1	0	0	1
NOBO	1	0	0	0	0	0	1	1	0	0

I determined outcomes for 86 red-winged blackbird nests; the fates of two nests were undetermined, and one nest was driven over by what looked like an ATV at Closson. Thirty-two nests were believed to have succeeded (36.4%) and 54 failed (61.4%). The driven over nest and the two undetermined nests were not included for survival calculations. There were 952 red-winged blackbird exposure days (46.5 egg laying, 562.5 incubation, 339 nestling). With 53 nests failing naturally, the Mayfield DSR was 0.944. Using an average of 25 days from first egg to fledging (4 egg laying days, 11 incubation, 10 nestling) the overall nest success for red-winged blackbirds was 23.88%. No nests failed during the egg laying stage, and the incubation stage DSR and survival probability was 0.929 and 44.4% as 40 nests failed during this stage. For the nestling stage the DSR and survival probability was 0.962, and 67.6% since 13 nests failed during the nestling stage.

The apparent nest success of dickcissels was 50%, as 23 nests both fledged and failed. The 46 nests were monitored for 459 days (27.5 egg laying, 257.5 incubation, 174 nestling). Using an average nesting length of 25 days (4 egg laying, 12 incubation, 9 nestling), the Mayfield DSR for dickcissels was 0.949, with an overall estimated nest success of 27.66%. One nest failed during the laying stage for a DSR of 0.964, and a survival probability of 86.2%. There were 257.5 incubation days which resulted in the loss of 18 nests. The DSR for this phase was 0.922, and the survival probability was 37.61%. During 174 nestling days, four nests failed for a DSR of 0.977, and a survival probability of 81.1%.

American goldfinch nests with known outcomes (n = 54) were monitored for 896.5 exposure days (Tables 5 & 6). Thirty-two (58.18%) nests fledged at least one

nestling. Nests during the lay stage accounted for 77 exposure days, 372 during incubation, and 447.5 with nestlings. The DSR for the species was 0.976 with an overall estimated nest success rate of 45.9% for an average 32 days nesting period (5 egg laying, 13 incubation, 14 nestling). The lay stage DSR was 0.97 (2 nests lost) and the survival probability was 87.7%. The incubation DSR was 0.96 with a survival probability of 58.6% (15 nests lost). The nestling DSR was 0.989 (5 nests lost) with a fledging probability of 85.4%.

At control nests, 10 of the 25 nests were successful. These nests were monitored for 284 exposure days, and 15 nests failed (DSR = 0.947, survival probability = 17.62%). Two nests were lost over 26.5 lay days, for a DSR of 0.92 and a survival probability of 67.6%. Eleven nests failed during 115.5 incubation days for a DSR of 0.90 and a stage success rate of 27.2%. Two nests failed during 142 nestling days, for a stage DSR of 0.986 and a success rate of 82%. Of the 25 nests, simulated manipulation was performed on 12 of them due to the timing of nest failure. There were eight post-simulation incubation exposure days and all nests made it to the nestling stage. Two of the nests failed over 127.5 post-simulation nestling days, for a DSR of 0.98 and a success rate of 80%. Non-simulated nests survived 67 exposure days (17 lay, 2 failures, 50 incubation, 11 failures), resulting in much lower DSR and survival probability.

At raised nests, 2 of 11 nests failed, one each during incubation and the nestling stage. Over 218.5 exposure days, the DSR was 0.991 and the estimated success rate was 74.88%. Over 84.5 total incubation days, the DSR was 0.988 and the success rate was 85.7%. Over 16 post-manipulation incubation days, the DSR was 0.938 and the success rate was 43.2%. Over 115.5 nestling days, the DSR was 0.991 and the estimated fledge

success rate was 88.5%. Using 109.5 post-manipulation nestling days the DSR was 0.991 and the fledge success rate was 87.9%.

For 19 lowered nests, 13 fledged, five failed, and one was undetermined. Failures occurred over 394 exposure days. Over 172 total incubation days and one failure, the DSR was 0.994 and the success rate was 92.7%. 39.5 post-manipulation days were during this stage resulting in a lower DSR of 0.975 and an estimated success rate of 71.7%. Over 190 nestling days and four failures, the DSR was 0.979 and the fledge success rate was 74.2%. With 161.5 post-manipulation exposure days, the DSR was 0.975 and the fledge success rate was 70.4%.

Of the remaining species, 10/19 field sparrow, 7/12 common yellowthroat, and 5/9 American robin nests succeeded. One of four indigo bunting nests fledged, all three mourning dove nests succeeded, and two of the three brown thrasher nests fledged. One of two eastern towhee, song sparrow, eastern kingbird, and ring-necked pheasant succeeded. The single mallard, northern bobwhite, and Henslow's sparrow nests all fledged. The eastern meadowlark nest was most likely destroyed by a tractor mower during incubation.

Brown-headed Cowbird Parasitism

Brown-headed cowbirds parasitized the nests of red-winged blackbirds (7 nests, 7 individuals, 2 fledglings), dickcissel (6 nests, 7 individuals, all failed to fledge), field sparrow (3 nests, 3 individuals, 2 fledglings), common yellowthroat (2 nests, 2 individuals, 1 fledgling), and indigo bunting (3 nests, 6 individuals, 1 fledgling). Of the 25 individuals in nests, only six were believed to have fledged.

Table 3. Exposure days and daily survival rates (DSR) for species and stages excluding AMGO. Separated into total DSR, and also for the stages of egg laying (Lay), incubation (Inc), and nestling (Nest).

Species	Fail/Days	DSR	Lay Fail/Days	Lay DSR	Inc Fail/Days	Inc DSR	Nest Fail/Days	Nest DSR
RWBL	53/952	0.944	0/46.5	100	40/562.5	0.929	13/339	0.962
DICK	23/459	0.949	1/27.5	0.964	18/257.5	0.922	4/174	0.977
FISP	9/183.5	0.951	0/6	100	8/87.5	0.909	1/90	0.989
COYE	5/139.5	0.964	0/8.5	100	3/79	0.962	2/52	0.962
AMRO	4/109.5	.964	0/4	100	4/49	.918	0/56.5	100
INBU	3/73	.959	0/1.5	100	2/52.5	.962	1/19	.947
BRTH	1/41	.976	0/1.5	10	1/19	.947	0/20.5	100
EAKI	1/30	.967	0/2.5	100	1/15.5	.935	0/12	100
EATO	1/27	.963	NA	NA	0/16	100	1/11	.91
SOSP	1/32	.969	0/1	100	0/17	100	1/14	.929
RNEP	1/14	.929	NA	NA	1/14	.929	NA	NA

Table 4. Nest survival for all species and stages excluding AMGO. Separated into overall probability, and for each stage of the nesting period.

Species	Nest Survival (%)	Lay Survival (%)	Incubation Survival (%)	Nestling Survival (%)
RWBL	23.88	100	44.4	67.6
DICK	27.66	86.2	37.61	81.1
FISP	33.1	100	34.8	91.5
COYE	40.2	100	62.8	70.3
AMRO	34	100	33.1	100
INBU	35	100	62.8	58.2
BRTH	51.3	100	49.5	100
EAKI	22.5	100	36.77	100
EATO	37.5	NA	100	38.6
SOSP	42.4	100	100	47.7
RNEP	7.78	NA	7.78	NA

Comparison of Nest Site Characteristics: Perceived Vs. Actual

To determine any differences between perceived and actual vegetation characteristics, paired Student's t-tests were performed. Statistical tests moving forward will represent actual vegetation coverage within a Daubenmire frame to understand the entire microsite composition being selected. Of the four species with the most nests monitored, it was common for bare ground and litter cover to be significantly under-reported using the 'with obstruction' method since the prairie floor was often highly obstructed by grass, forbs, woody vegetation, and standing dead vegetation.

An established litter layer with little bare ground resulted in litter cover being under-represented to a higher degree than bare ground. Forbs, grasses and dead vegetation were usually significantly under-reported using the 'with obstruction' method but were more representative of the actual coverage when compared with litter cover. Since woody vegetation was usually taller than other vegetation, both methods yielded either the same coverage or slightly more coverage using 'without obstruction' collection for this variable.

Table 5. Daily survival rates for American goldfinch nests divided by treatment group. Manipulated nests were grouped by both the entire exposure days, and post-manipulation exposure days.

AMGO Nests	Fail/Days	DSR	Lay Fail/Days	Lay DSR	Incubation Fail/Days	Incubation DSR	Nest Fail/Days	Nest DSR
All Nests	22/896.5	0.976	2/77	0.97	15/372	0.96	5/447.5	0.989
All Control	15/284	0.947	2/26.5	0.92	11/115.5	0.9	2/142	0.986
Simulated Manipulation Control	2/127.5	0.985	NA	NA	0/8	100	2/127.5	0.98
Non-simulated Control	13/67	0.806	2/17	0.882	11/50	0.78	NA	NA
All Raised	2/218.5	0.991	0/18.5	100	1/84.5	0.988	1/115.5	0.991
Manipulated Raised	2/125.5	0.984	NA	NA	1/16	0.94	1/109.5	0.991
All Lowered	5/394	0.987	0/19	100	1/172	0.994	4/190	0.979
Manipulated Lowered	5/201	0.975	NA	NA	1/39.5	0.975	4/161.5	0.975

Table 6. Nest Survival Probability for American goldfinch nests separated by treatment. Manipulated nests were grouped by both the entire exposure days, and post-manipulation exposure days.

AMGO Nests	**Survival Probability (%)**	**Lay Survival (%)**	**Incubation Survival (%)**	**Nestling Survival (%)**
All Nests	45.96	87.7	58.6	85.4
All Control	17.5	67.6	27.2	82
Simulated Manipulation Control	61.65	NA	100	80
Non-simulated Control	0.1	53.48	3.96	NA
All Raised	74.88	100	85.7	88.5
Manipulated Raised	59.68	NA	43.2	87.9
All Lowered	65.79	100	92.7	74.2
Manipulated Lowered	44.48	NA	71.7	70.4

Nest Site and Random Site Comparisons

Red-winged blackbird nest sites had significantly more woody vegetation and significantly less grass cover than random sites (Table 7). Dickcissel nest sites had significantly more woody vegetation cover than random sites, whereas grass and forb cover was significantly higher at random sites. Woody vegetation cover was significantly higher at American goldfinch nest sites, whereas forb and grass cover were significantly higher at random sites. These three species selected nest sites with significantly taller live vegetation and visual obstruction than random sites. Dead vegetation height was significantly taller at red-winged blackbird and dickcissel nest sites. Woody vegetation cover was significantly higher at field sparrow nests whereas all other differences between the sites were not significant. Common yellowthroat nest sites had more grass, woody vegetation, and dead vegetation, and American robin nests had more bare ground and woody vegetation cover (Table 8). Common yellowthroat nests had taller live and dead vegetation heights, thinner litter depth, and slightly higher visual obstruction. These four measurements were higher at American robin nests, most notably live vegetation height and visual obstruction.

The amount of concealment from both above and below nests was variable between species (Figure 12). Dickcissel and field sparrow nests sites resulted in the least severe paths from my walking (Figure 13). For the three most monitored species, paths left at dickcissel nests were significantly less severe than at American goldfinch and red-winged blackbird nest sites.

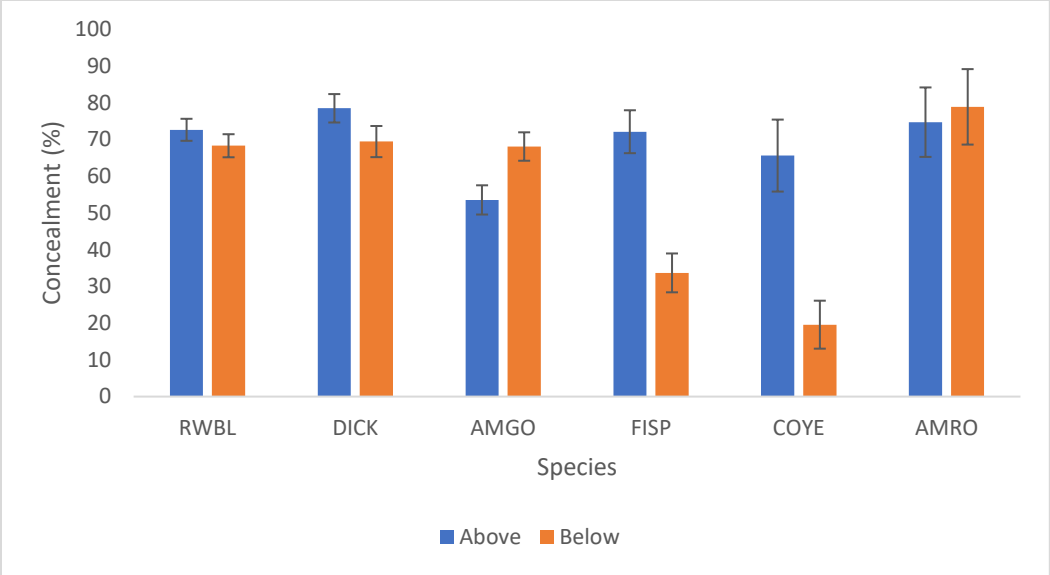

Figure 12. Concealment from both above (Above) and below (Below) for the six most common species. For AMGO, pre-manipulated values were used.

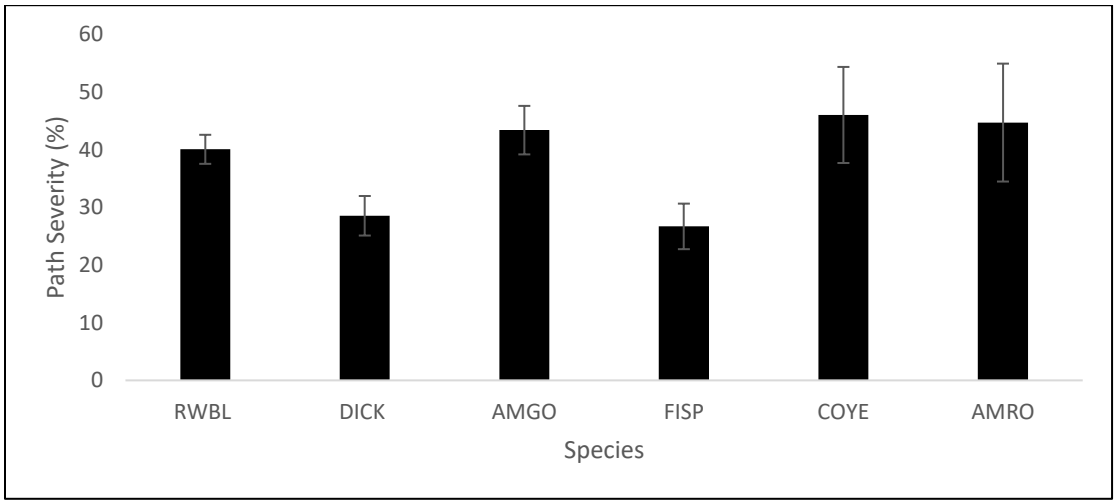

Figure 13. Path severity left at nests of the six most sampled species.

Nest Height and Relationships

Generally, nest height increased as substrate height increased (Figures 14-21). For all species, a polynomial trend-line explained 83% of variation ($r = 0.89$, $p < 0.001$). For the three species for which I found the most nests, there were strong positive correlations between nest height and substrate height (RWBL $r = 0.60$, $p < 0.001$; DICK $r = 0.77$, $p <$

0.001; AMGO r = 0.86, p < 0.001). American goldfinch nest height and substrate height were significantly taller than for both red-winged blackbirds and dickcissels, whereas the latter two were nearly identical.

Red-winged blackbird nest height was significantly positively correlated with substrate height, woody vegetation cover, live vegetation height, visual obstruction, and concealment from below (Table 9). A negative relationship approaching significance was found with dead vegetation cover, and there was a significant negative relationship with grass cover. Concealment from above and below the nests were significantly positively correlated (p = 0.0091) and "below concealment" was significantly positively correlated with nest height (p = 0.041).

Multiple regression backward modeling for nest height predictors was described by positive terms for substrate height, the cover of forbs, grass, wood, and dead vegetation, and live vegetation height and visual obstruction to the intercept, and negative terms for above concealment and path severity (Table 10). When added sequentially, grass cover and dead vegetation height were not significant at reducing variation. With all other variables added, substrate height, grass cover, and dead vegetation height were not significant additions, and live vegetation height approached significance (p = 0.067).

The overall model was significant (p < 0.001). There was high variance inflation for substrate height, forbs cover, grass cover, wood cover, and live vegetation height indicating strong correlation among at least some of the independent variables.

Table 7. Comparison of nest site and random site actual vegetation cover for RWBL, DICK, AMGO and FISP, including t-value and p-value

Vegetation Characteristic	RWBL			DICK			AMGO			FISP		
	Nest	**Random**	**t, p**	**Nest**	**Random**	**t, p**	**Nest**	**Random**	**t, p**	**Nest**	**Random**	**t, p**
Bare Ground	28.84	27.77	0.66, 0.51	11.72	13.22	-0.64, 0.53	16.09	16.32	-0.12, 0.91	16.58	23.68	-1.52, 0.15
Litter	68.87	69.91	-0.6, 0.55	78.17	76.89	0.53, 0.6	73.36	75.09	-0.65, 0.52	73.55	64.21	1.65, 0.12
Forbs	66.25	61.37	1.5, 0.13	32.11	49.5	-2.48, 0.017	24.5	45.64	-5.26, < 0.001	58.29	58.16	0.02, 0.98
Grass	26.76	31.7	-2.1, 0.039	30.56	38.11	-2.12, 0.04	26.59	35.68	-3, 0.004	31.45	32.5	-0.14, 0.89
Wood	15.24	3.36	4.06, < 0.001	65.67	6.5	10.73, < 0.001	76.86	13.36	16.45, < 0.001	17.5	3.82	2.35, 0.03
Dead Vegetation	18.48	19.49	-0.77, 0.44	21.56	23.61	-1.18, 0.24	28	31.22	-1.32, 0.19	20.92	24.74	-1.19, 0.25
Live Veg Height	94.71	59.54	11.07, < 0.001	93.78	52.8	6.58, < 0.001	181.64	78.91	12.44, < 0.001	74.89	57.53	2.96, 0.0085
Dead Veg Height	35.37	28.52	3.68, < 0.001	45.29	31.02	4.19, < 0.001	44.05	40.31	1.11, 0.27	41.26	30.42	2.47, 0.024
Litter Depth	2.54	2.64	-0.6, 0.55	3.05	2.82	1.06, 0.3	2.85	2.65	1.01, 0.32	1.71	1.87	-0.63, 0.53
Visual Obstruction	6.33	5.2	7.41, < 0.001	6.07	4.53	5.17, < 0.001	5.71	4.88	2.83, 0.007	4.55	4.3	0.92, 0.37

Table 8. Comparison of nest site and random site actual vegetation cover for COYE and AMRO.

Vegetation Characteristic	COYE				AMRO			
	Nest	SE	Random	SE	Nest	SE	Random	SE
Bare Ground	11.46	3.85	13.75	4.78	14.44	4.76	9.44	2.2
Litter	75.42	4.5	77.29	4.4	65.83	8.76	75	3.95
Forbs	35.21	8.18	51.88	9.28	40.83	8.27	53.89	13.41
Grass	29.58	6.39	27.29	6.32	20	3.31	33.06	8.53
Woody Vegetation	14.58	6.61	2.5	0	89.44	3.93	7.78	3.96
Dead Vegetation	32.29	5.12	20.63	2.94	17.5	2.5	25	3.95
Live Vegetation Height	67.75	10.63	51.83	8.24	162.78	15.23	52.67	8.71
Dead Vegetation Height	57.33	8.84	32.75	7.58	40.56	6.59	30.44	5.45
Litter Depth	2.08	0.36	2.54	0.49	2.72	0.66	2.58	0.6
Visual Obstruction	5.04	0.7	4.88	0.79	6.56	0.79	4.81	0.66

Forward modeling included positive terms for substrate height, woody vegetation cover, visual obstruction, and live vegetation height to the intercept, and negative terms for path severity and above concealment. Above nest concealment was the only non-significant term when added sequentially. After all other variables were added, substrate height was the only non-significant addition. This model was significant ($p < 0.001$) and only substrate height and live vegetation height showed high variance inflation, both values being lower than backward modeling.

Another way to visualize how nest height was being affected by vegetation properties was by using Principle Components Analysis (PCA). By having a large number of variables, components were identified by how much variation in the data was explained. Components explaining more than 10% of the overall variance were selected, resulting in the first four components for red-winged blackbirds, accounting for 67.04% of the variation. Of the four, the second component ($r = 0.69$, $p < 0.001$) was significant (Table 11). Nest height was positively correlated with everything but bare ground and forbs. Substrate height, woody vegetation, live vegetation height, and visual obstruction had loading at or above 0.45, indicating these measurements were most important for red-winged blackbird nest height.

Dickcissel nest height was significantly positively correlated with substrate height, woody vegetation cover, live vegetation height, and visual obstruction. A nearly significant positive relationship was found with concealment from below. There was a nearly significant negative relationship between nest height and forb cover, and a significant negative correlation with grass and dead vegetation cover.

The final backward model for dickcissel included positive terms for substrate height, woody vegetation cover, live vegetation height and visual obstruction to the intercept, and negative terms for bare ground, litter, and above concealment. Substrate height, bare ground, visual obstruction and concealment from above were significant sequential additions, and after all other variables were added, live vegetation height, visual obstruction and above concealment were significant. The model was significant ($p < 0.001$). Substrate height, bare ground, and litter had high inflation. Using forward modeling, the final model showed the addition of live vegetation height, woody vegetation cover, visual obstruction, and substrate height to the intercept, and subtracting above concealment. All but substrate height was significant when added sequentially and only substrate height was not significant when added to a model with the other terms. Live vegetation height and substrate height had high inflation.

The first four components were selected for dickcissels, accounting for 66.1% of the variance. The first two components were significantly correlated with nest height (PCA 1 $r = 0.47$, $p = 0.001$; PCA 2 $r = 0.66$, $p < 0.001$). The first component can be summarized as a short vegetation patch covered with dense and deep litter, and more woody vegetation than grass or forbs. The moderate height will still provide some vertical density, but sacrificed concealment from above with increased concealment from below. The second component has much taller woody vegetation about equal to the average height in the plot, some tall dead vegetation mixed in, less litter depth, and better concealment from above than below.

American goldfinch nest height was significantly positively correlated with substrate height and live vegetation height. These nests were the least protected by

vegetation from above. Concealment from above at American goldfinch nests was significantly lower than both red-winged blackbird and dickcissel, whereas the latter two were not significantly different. From below, there were no significant differences for concealment for these three species.

The final backward and forward model converged with positive terms for substrate height, litter, and below concealment to the intercept, and above concealment was a negative term. All terms were significant when added sequentially. The model was significant ($p = 2.2e-16$) and when each term was added to the model with all other terms, substrate height and below nest concealment were significant. Above concealment approached significance ($p=0.0523$) and litter did not approach significance ($p = 0.16$).

The first five components of the PCA analysis were selected for American goldfinch nests and accounted for 66.4% of the variance. Of the five, only the third was significant, with a strong positive correlation ($r = 0.77$, $p < 0.001$). This component shows about equal tall heights for substrate height and overall live vegetation height, and moderate dead vegetation height. Concealment from above is low, but is high from below. Woody vegetation outweighs grass and forbs slightly.

The first three components were selected for field sparrow nests, explaining 65.9% of the variance. The first component was significant ($r = 0.74$, $p < 0.001$) with nest height. Nest height responded in a strong positive manner with substrate height, grass cover and live vegetation height, while negatively to almost everything else, most notably dead vegetation cover, dead vegetation height, and concealment from both directions.

Nest Site Characteristics

An ordination plot was produced for comparison purposes for the three most common species (RWBL, AMGO, DICK, Figures 22-23), and the next three most common (FISP, COYE, AMRO, Figures 24-25). These were separated so no points were lost on a single plot with over 200 samples, and groupings would be easier to determine based on similar nest-site characteristics. Every vegetation characteristic, including nest height, was used to determine what microsite structure was selected by each species. There was slight overlap of the top three species surrounding a cluster of variables including visual obstruction, concealment from below, and litter depth. American goldfinch and dickcissel nests were more clustered toward the top half of the plot due to their affinity with nesting in woody vegetation. American goldfinch nests were almost exclusive to the right half of the plot because of the cluster of nest and substrate height and live vegetation height. Red-winged blackbirds were spread throughout the left half of the plot, lower than dickcissels, because red-winged blackbirds mostly nested in forbs, and on occasion, woody vegetation.

American robins were clustered toward nest height, woody vegetation, and concealment from below, whereas field sparrow and common yellowthroat were scattered about with the bulk of the remaining variables. Field sparrows were weighted toward concealment from above and forb cover, whereas common yellowthroats were closer to regions with dead vegetation height and path severity.

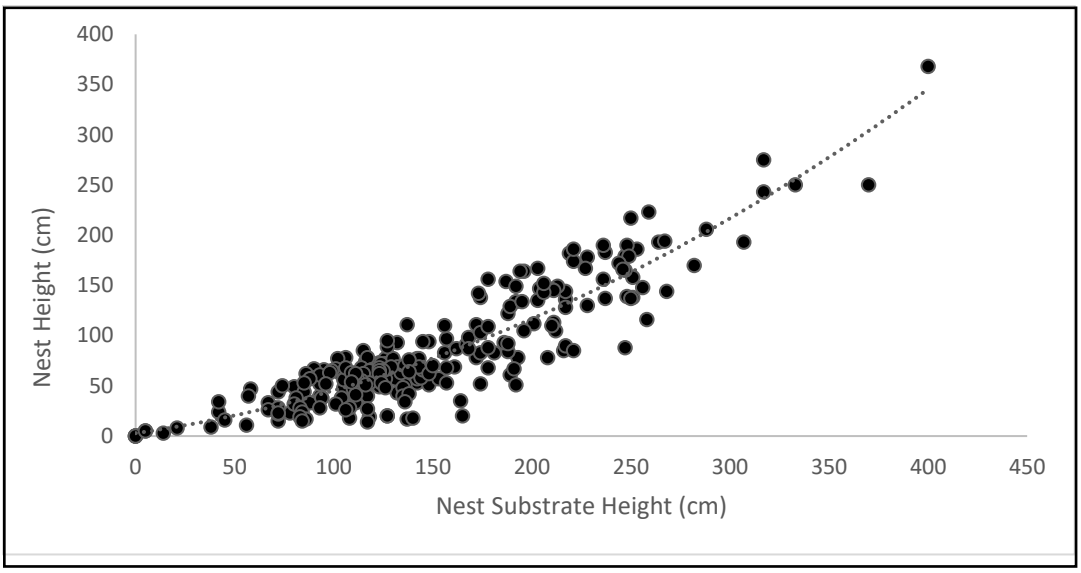

Figure 14. Nest height as a function of substrate height for all nests found from the grassland bird community. The distribution is fitted with a polynomial trend line (R^2 = 0.83, $p < 0.001$).

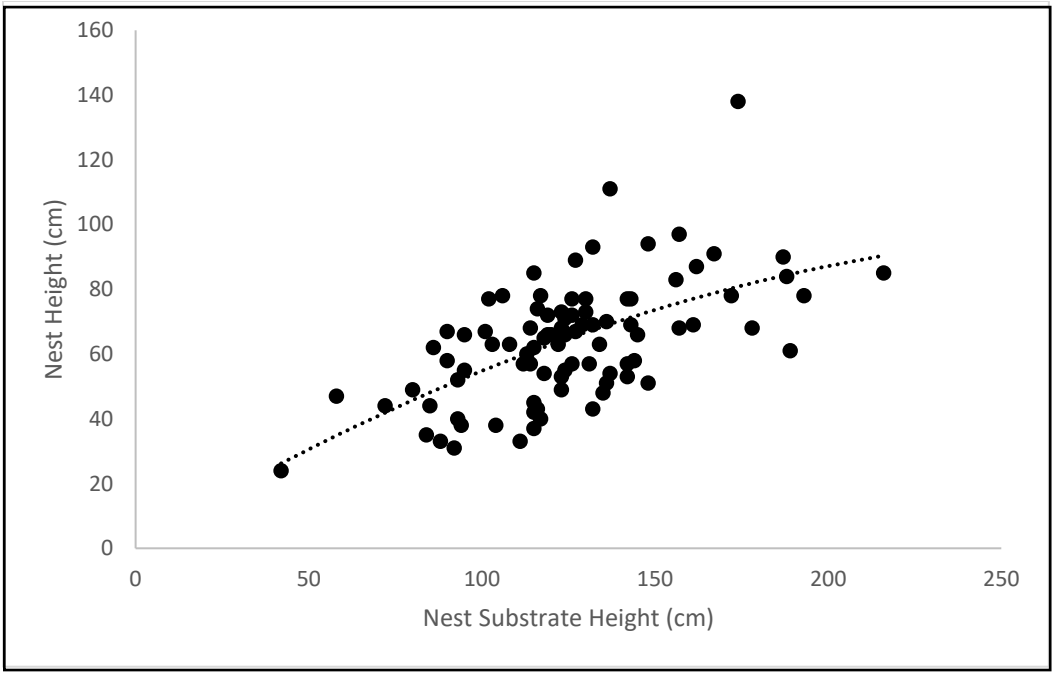

Figure 15. Relationship of red-winged blackbird nest height and substrate height. The distribution was fitted with a polynomial trend-line ($R^2 = 0.35$, $p < 0.001$).

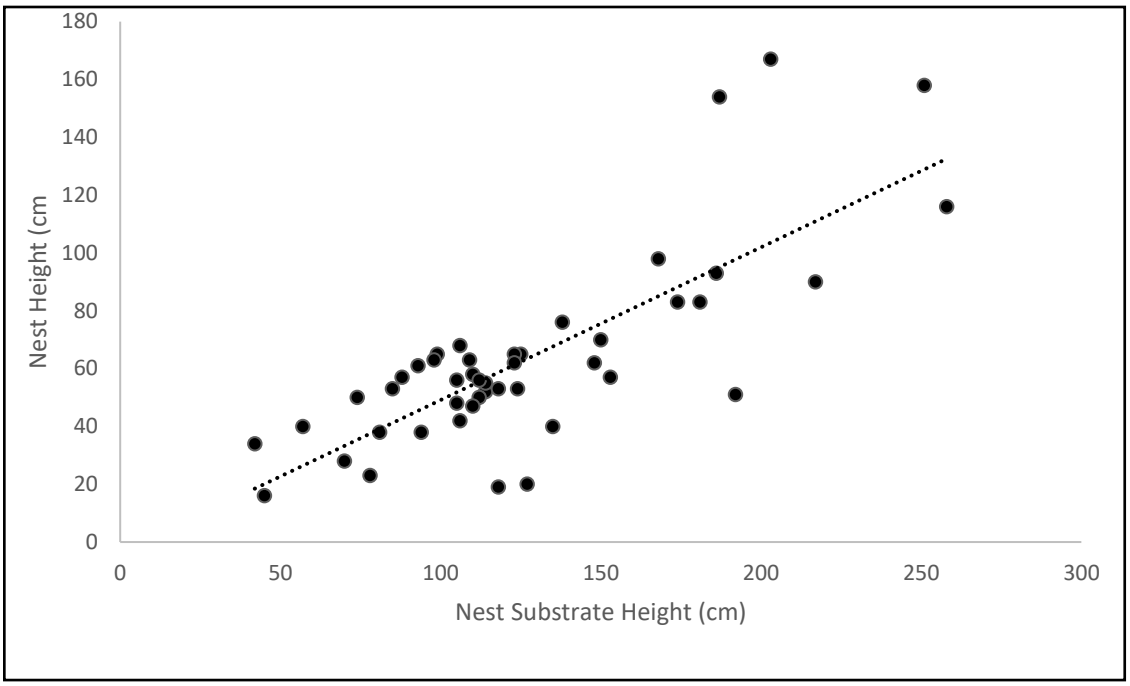

Figure 16. Relationship of dickcissel nest height and substrate height. The distribution was fitted with a linear trend-line ($R^2 = 0.61$, $p < 0.001$)

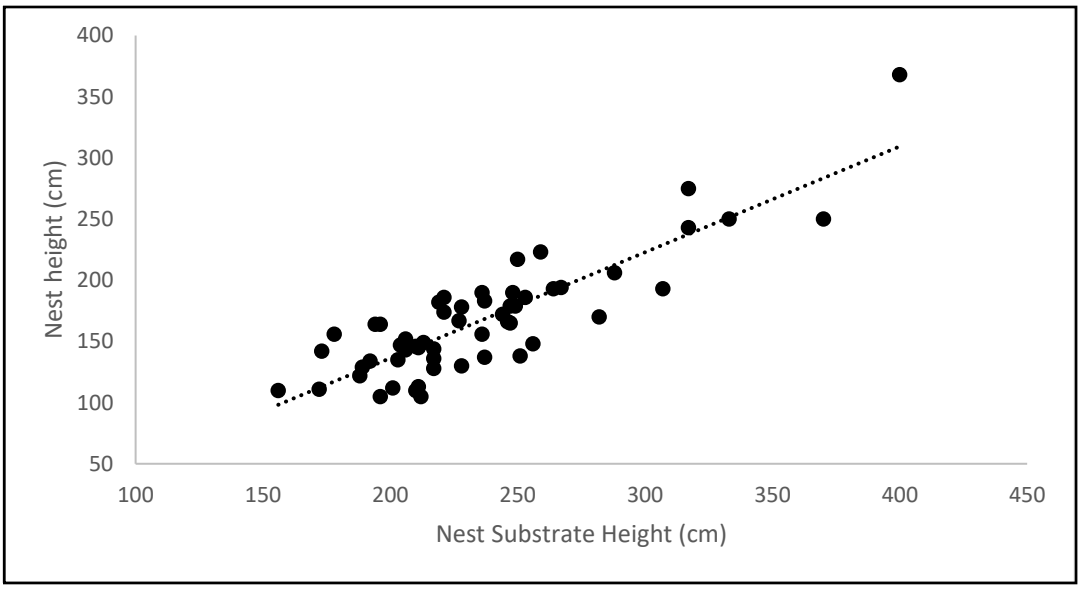

Figure 17. Relationship of American goldfinch nest height and primary substrate height. The distribution is fitted with a linear trend-line ($R^2 = 0.74$, $p < 0.001$)

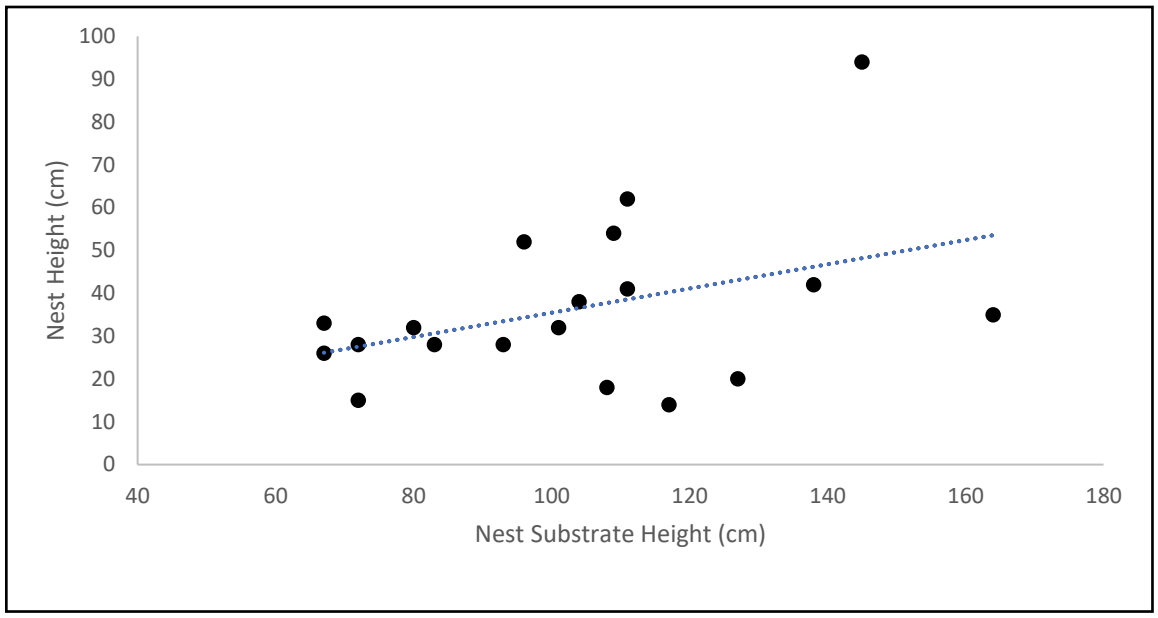

Figure 18. Relationship of field sparrow nest height and substrate height. The distribution is fitted with a linear trend-line ($R^2 = 0.16$, $p = 0.09$).

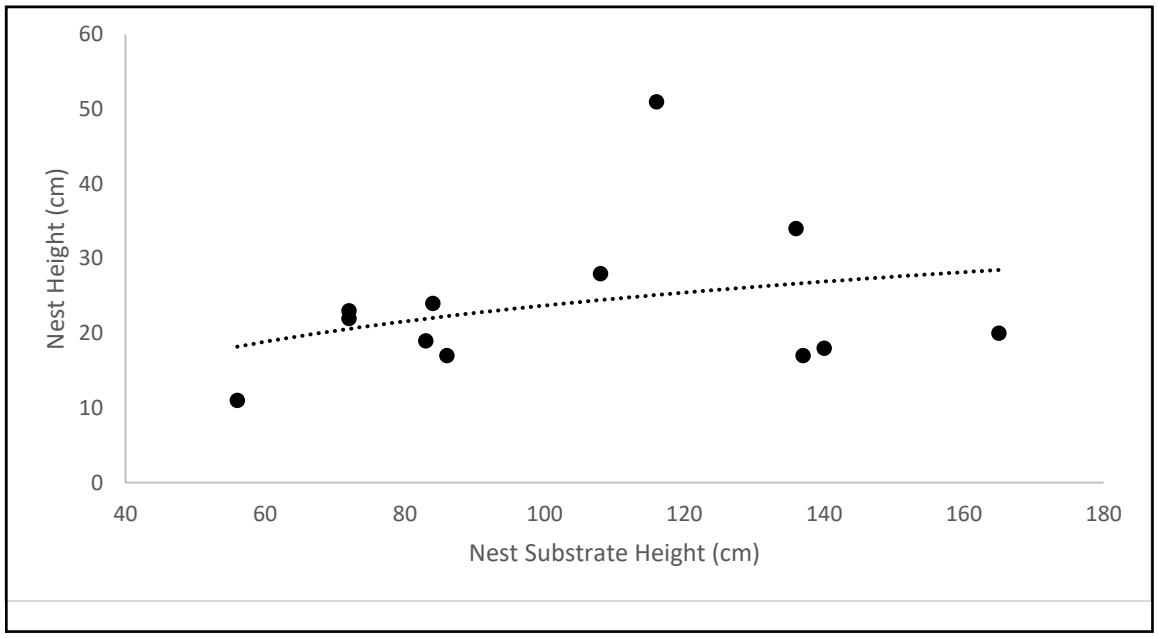

Figure 19. Relationship of common yellowthroat nest height and substrate height. The distribution is fitted with a logarithmic trend-line ($R^2 = 0.09$, $p = 0.46$).

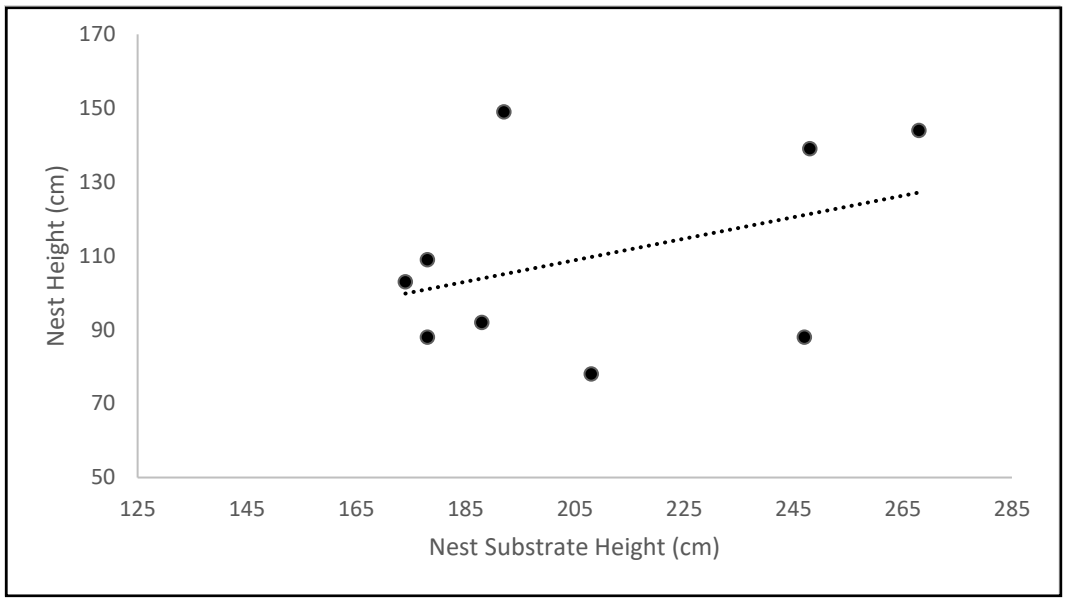

Figure 20. Relationship of American robin nest height and substrate height. The distribution is fitted with a linear trend-line (R^2 = 0.15, p = 0.31).

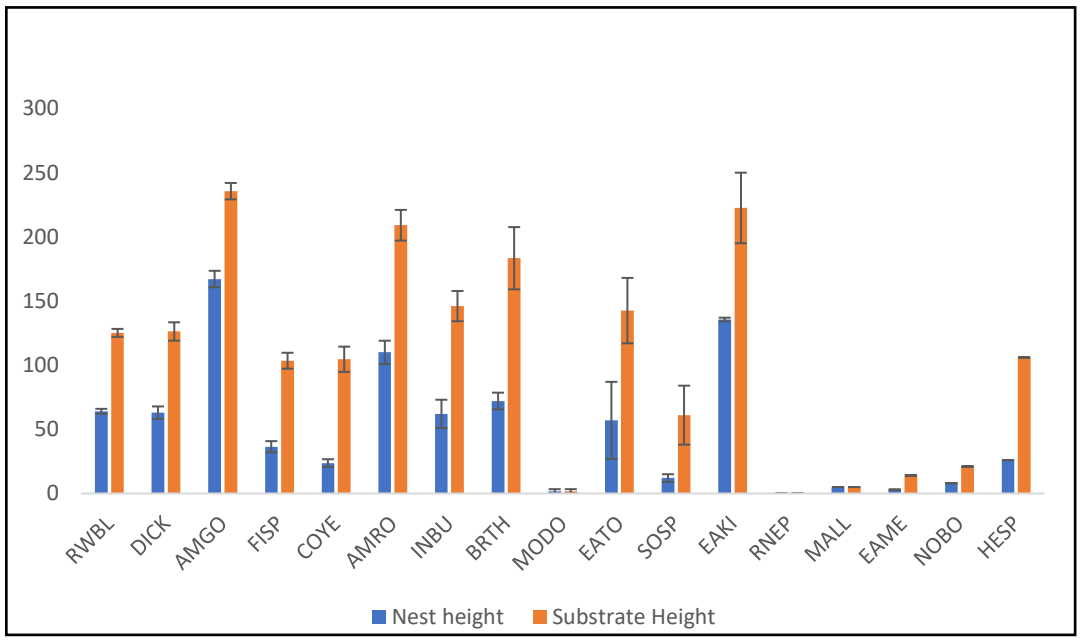

Figure 21. Average nest height and substrate height for each species found during the study with standard error bars.

Table 9. Correlations of vegetation properties to nest height for the four major species monitored. The r-value shows the direction and strength of the correlation, and the associated p-value.

Vegetation	**RWBL**		**DICK**		**AMGO**		**FISP**	
Characteristic	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**
Substrate Height	0.59	< 0.001	0.78	< 0.001	0.86	< 0.001	0.4	0.09
Bare Ground	0.028	0.8	-0.23	0.14	-0.06	0.66	-0.31	0.19
Litter	-0.02	0.83	0.22	0.15	0.07	0.63	0.23	0.35
Forbs	-0.12	0.27	-0.22	0.15	-0.1	0.46	-0.29	0.22
Grass	0.013	0.9	-0.19	0.22	-0.03	0.82	-0.17	0.49
Wood	0.39	< 0.001	0.4	0.006	-0.16	0.23	0.59	0.008
Dead Vegetation	-0.14	0.21	0.23	0.13	-0.02	0.87	0.63	0.004
Live Vegetation Height	0.59	< 0.001	0.79	< 0.001	0.55	< 0.001	0.33	0.16
Dead Vegetation Height	0.036	0.74	0.21	0.16	0.1	0.48	0.22	0.38
Litter Depth	-0.036	0.75	0.15	0.34	0.03	0.84	0.31	0.2
Visual Obstruction	0.39	< 0.001	0.4	0.006	0.004	0.98	0.69	0.001
Above Concealment	0.079	0.46	-0.23	0.13	-0.22	0.11	-0.3	0.21
Below Concealment	0.22	0.041	0.26	0.08	0.12	0.4	0.88	< 0.001
Path	-0.0008	0.99	0.11	0.48	0.03	0.83	0.35	0.14

Table 10. Multiple regression models predicting nest height. Variables were either added or subtracted to/from the intercept. Substrate height (SubH), Bare ground (BG), litter (L), forbs (F), grass (G), wood (W), dead vegetation (DV), Live vegetation height (LVH), dead vegetation height (DVH), visual obstruction from Robel Pole (VOR), concealment from above and below (Above, Below), path severity (Path).

Red-winged blackbird	**Intercept**	**Variables**	**p**	**R^2**
Backward	3.5	+ 0.44SubH + 0.16F + 0.12G + 0.33 W + 0.20LVH + 0.09 DVH + 2.23RP - 0.12Above - 0.13Path	< 0.001	0.64
Forward	18.44	+ 0.13SubH + 0.22W + 2.41VOR - 0.12Path - 0.09Above + 0.22LVH	< 0.001	0.62
Dickcissel				
Backward	47.7	+ 0.2SubH -0.8BG -0.49L + 0.14W + 0.33LVH + 3.52VOR -0.32Above	< 0.001	0.8
Forward	1.54	+ 0.34LVH - 0.32Above + 0.19W + 2.95RP + .19SubH	< 0.001	0.78
American goldfinch				
Both Directions	-57.18	+ 0.87SubH + 0.21L -0.21Above + 0.22Below	< 0.001	0.79

Table 11. Nest Height variable loadings/correlation between the original data and the significant PCA axes for each species. This shows the direction and strength of the correlation of each variable in the PCA to nest height.

Variable	RWBL PCA 2	DICK PCA 1	DICK PCA 2	AMGO PCA 3	FISP PCA 1
Substrate height	0.72	0.12	0.84	0.86	0.34
Bare Ground	-0.18	-0.84	0.15	0.012	-0.056
Litter	0.18	0.89	-0.2	0.036	0.14
Forbs	-0.37	-0.19	-0.48	-0.16	-0.27
Grass	0.21	-0.3	-0.13	-0.11	0.67
Wood	0.51	0.21	0.7	-0.13	-0.32
Dead Vegetation	0.076	0.19	0.28	-0.11	-0.47
Live Vegetation height	0.68	0.3	0.75	0.89	0.52
Dead Vegetation height	0.18	-0.59	0.5	0.31	-0.47
Litter Depth	0.12	0.72	-0.35	0.048	0.1
Visual Obstruction	0.45	0.46	0.92	-0.12	-0.052
Concealment From Above	0.27	-0.41	0.15	-0.23	-0.37
Concealment From Below	0.33	0.68	-0.58	0.17	-0.37
Path Severity	0.15	0.14	-0.4	0.028	-0.21

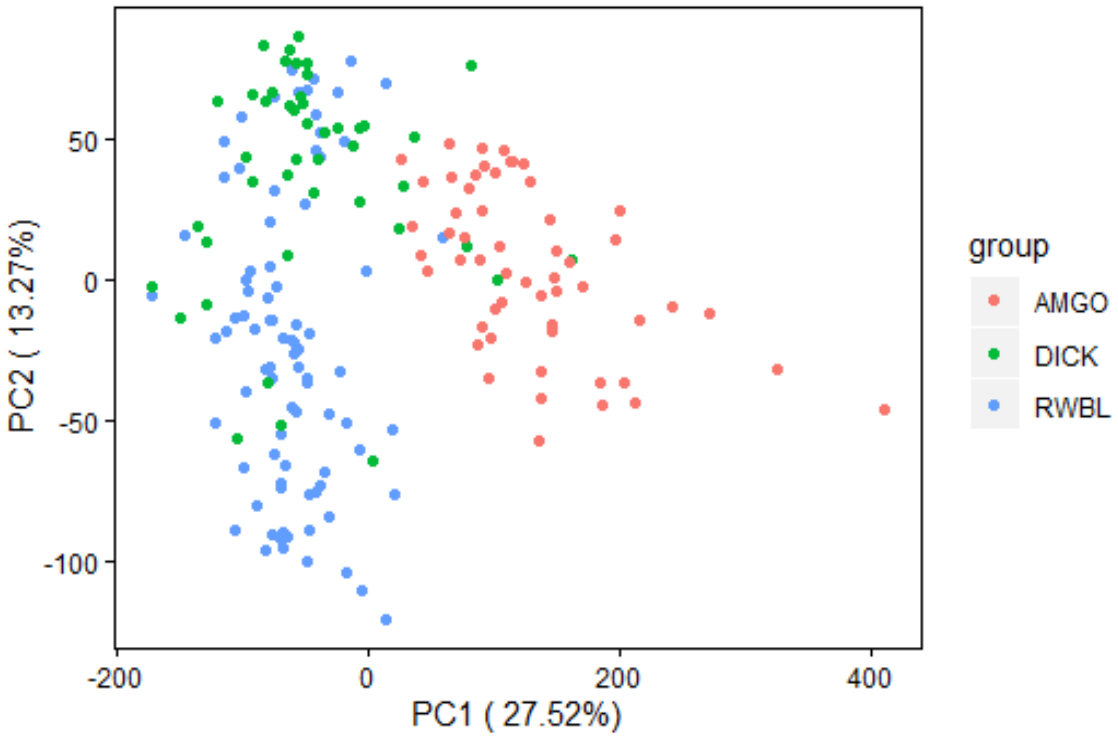

Figure 22. Ordination of nest site vegetation properties including actual vegetation cover for red-winged blackbird, dickcissel and American goldfinch. The percentages of variation expressed by each axis are in parentheses.

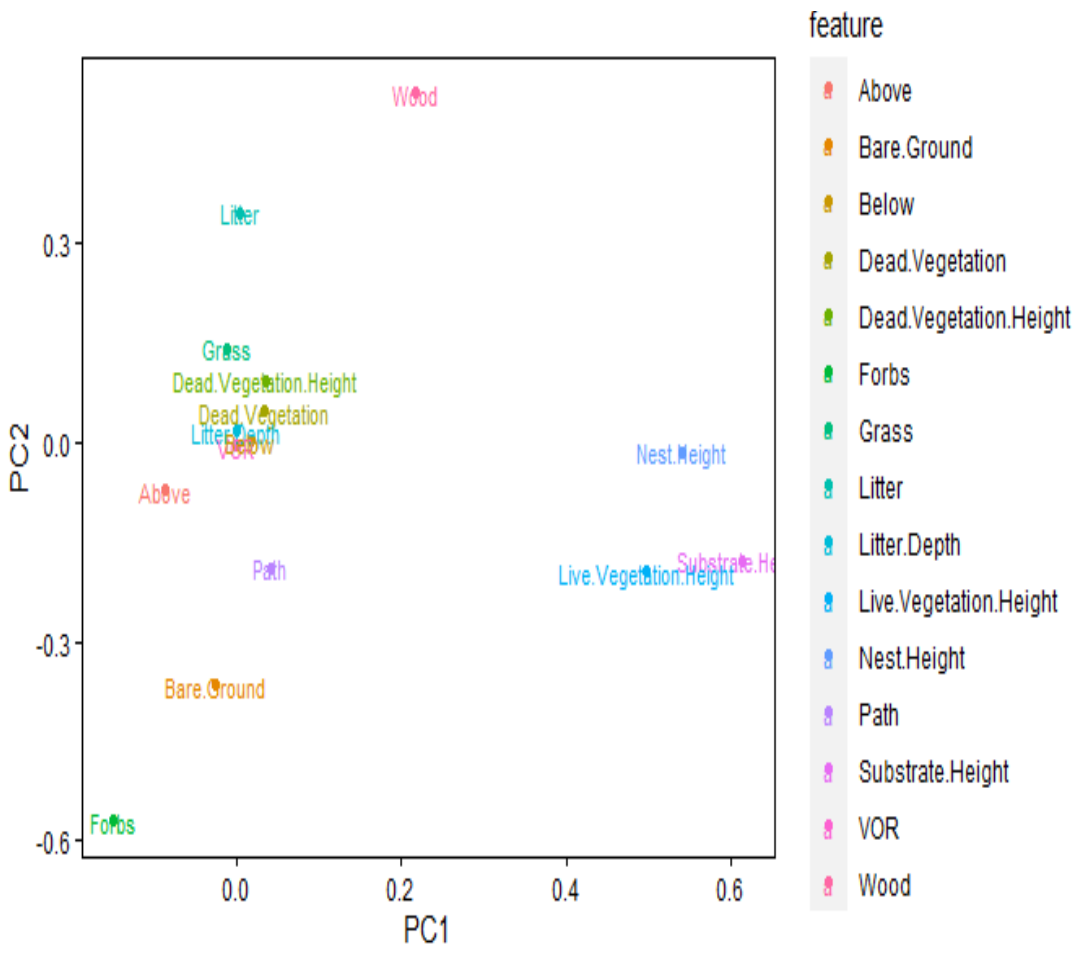

Figure 23. Vegetation characteristics driving the distribution of data points for RWBL, DICK, and AMGO nest site selection.

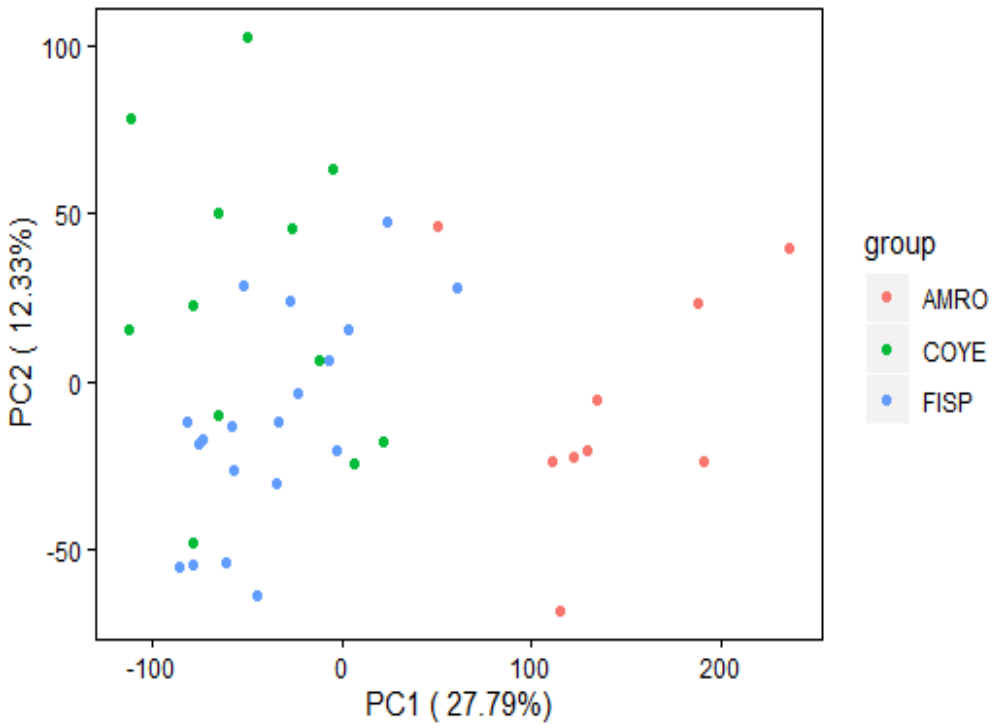

Figure 24. Ordination of nest site vegetation properties including actual vegetation cover for field sparrow, common yellowthroat and American robin. The percentages of variation expressed by each axis are in parentheses.

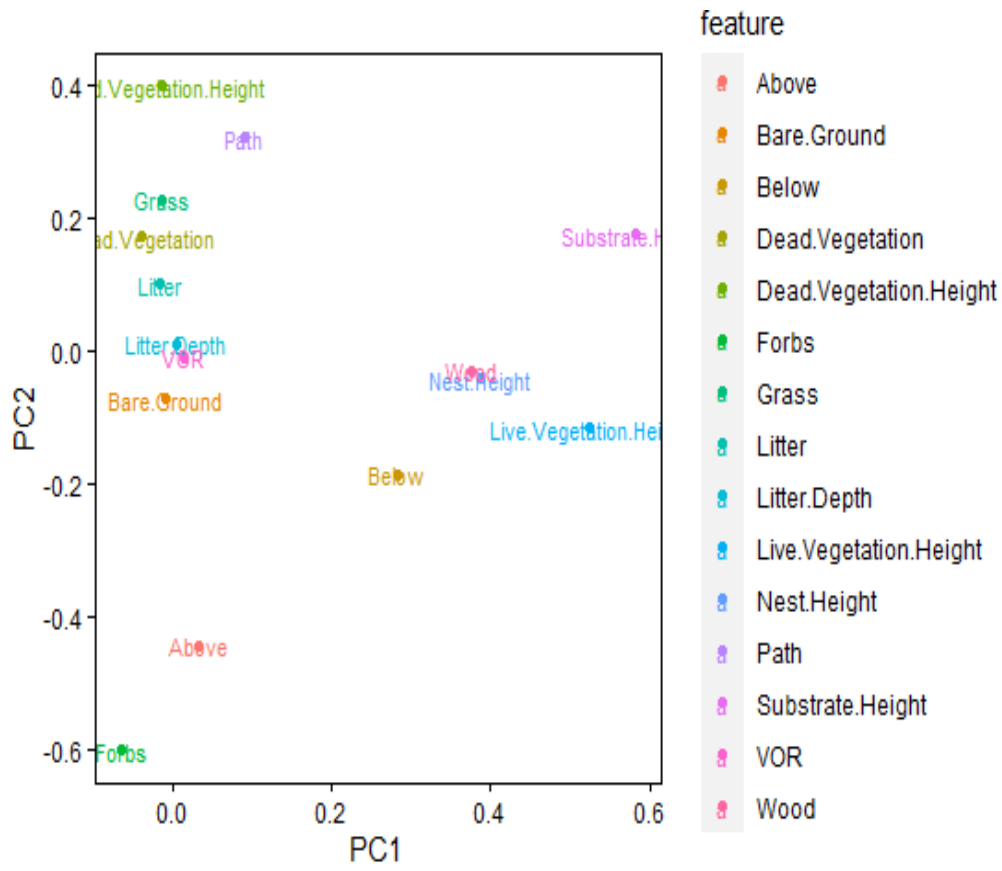

Figure 25. Vegetation characteristics driving the distribution of data points for FISP, COYE, and AMRO nest site selection.

Factors Affecting Nest Outcomes

Red-winged blackbird nest height averaged 64 cm. There was no significant difference between height for successful and failed nests ($t = 0.16$, $df = 83$, $p = 0.87$) (Figure 26). Successful nests had significantly taller nest substrate ($t = 2.29$, $df = 83$, $p = 0.024$) (Figure 27), and successful nests had more bare ground, which approached significance (Table 12). There were significantly more-worn paths around successful red-winged blackbird nests. Logistic regression found a non-significant increase in survival probability of 0.23% and 1.8% with a 1 cm increase in nest height and substrate height, respectively (Table 13). Visual obstruction carried a 4.2% decrease in survival for every 1 dm increase, as failed nests had slightly more dense vegetation. Path severity was significantly associated with survival probability, as an increase of 1% path severity meant a 6.75% increase in red-winged blackbird survival.

The average dickcissel nest was 63 cm high with an almost 20cm difference between successful and failed nests that approached significance ($t = 2.03$, $df = 28.421$, $p = 0.052$). Two failed nests that either had unviable eggs or were abandoned were excluded from the direct comparison. The difference between substrate height for successful and failed nests also approached significance ($t = 1.90$, $df = 42$, $p = 0.065$). There was more dead vegetation cover at successful dickcissel nests, which fell outside significance ($p = 0.053$). Despite no significant variables between failed and successful nests or with survival predictors, a 1 cm increase in dickcissel nest height resulted in a 2.31% increase in survival probability (Table 14). A 1% increase in dead vegetation cover had a 6.02% increased effect on survival probability, and visual obstruction (8.26% with a 1 dm increase), and litter depth (24.8% with a 1 cm increase) were important

variables for dickcissel survival probability, despite non-significant effects. There were no significant differences between red-winged blackbird and dickcissel nest height or substrate height for both successful and failed nests.

The average field sparrow nest height was 36.4 cm. Successful nests were lower than failed nests, and the difference approached significance ($t=-1.98$, $df = 17$, $p=0.064$). The difference in successful and failed substrate height also approached significance ($p = 0.087$). There was significantly more bare ground at successful field sparrow nests. Field sparrow survival probability was positively influenced by increases of bare ground, dead vegetation height, and female agitation, and was highly negatively influenced by increase in nest height, visual obstruction, and male agitation score (Table 15).

The average common yellowthroat nest height was 23.67 cm. Successful nests were slightly higher than failed ones, however the small sample size should be noted (Figure 28). This prevented statistical comparison of successful and failed nest site characteristics (Table 16). American robin nest height averaged 110cm. Successful nests averaged 121.6cm ($n = 5$) and failed nests averaged 95.5cm ($n = 4$) (Figure 28). The small sample size should be noted, although the variation of failed nests was smaller than for successful nests. Successful nests were attached to higher vegetation, although there was high variation with the low sample sizes for nest fate groups.

Successful and failed American goldfinch nest sites were similar, but the most notable difference was increased woody vegetation at failed nests. American goldfinch nests stood an average of 160.37 cm at the time of their success or failure. There was not a significant difference between the heights of failed and successful nests, even when adjusting the height of nests based on exposure days pre- and post-manipulation; lowered

nests had an average height decrease of 28.37 cm and raised nests increased by an average of 15.91 cm. (Figure 29, Table 17). Nests that were unmoved in the control group averaged 178.56 cm in height. Among control nests, successful nests were significantly higher than failed nests ($t = 2.2$, $df = 11.56$, $p = 0.049$) (Figure 30).

There were 25 nests placed in the control group, and 13 failed prior to a simulated manipulation, whereas 2/12 simulated nests failed. These two groups had significantly different nest heights ($t = 2.76$, $p = 0.016$), with simulated nests being taller than non-simulated nests (simulated = 210.42 cm, SE = 21.03, non-simulated = 149.15 cm, SE = 7.08). Successful nests in the raised group were higher than failed nests, both before and after manipulation (Figure 31). In the lowered group, failed nests were slightly higher than successful nests both before and after manipulation, and this difference was not significant (Figure 32). There was not a significant difference of substrate height between successful and failed American goldfinch nests.

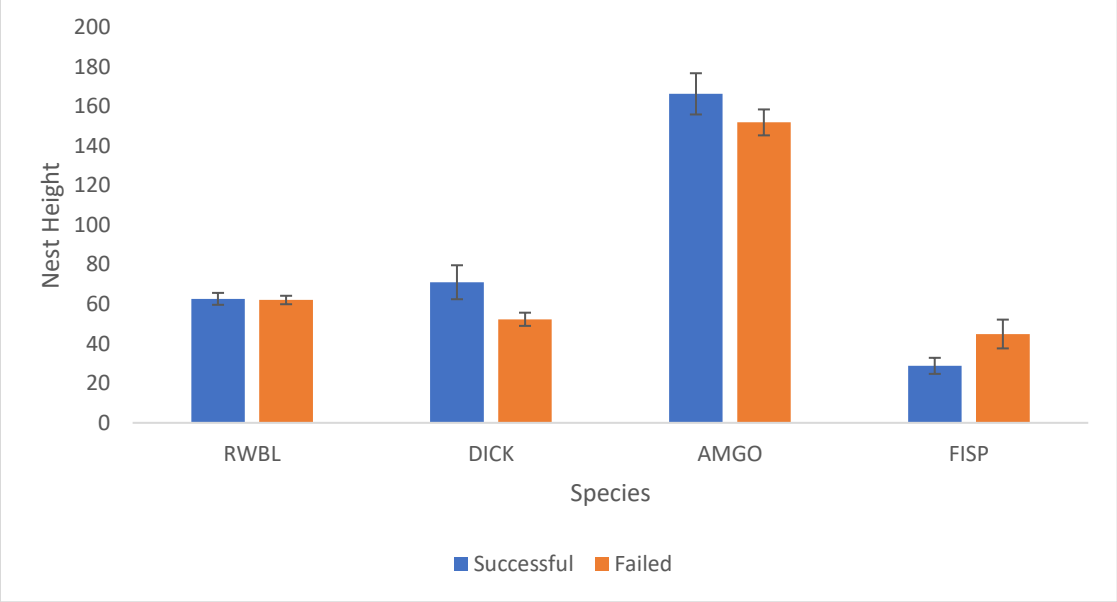

Figure 26. Nest height comparison of RWBL, DICK, AMGO, & FISP, separated into successful and failed nests. For AMGO, the final height was used for all nests.

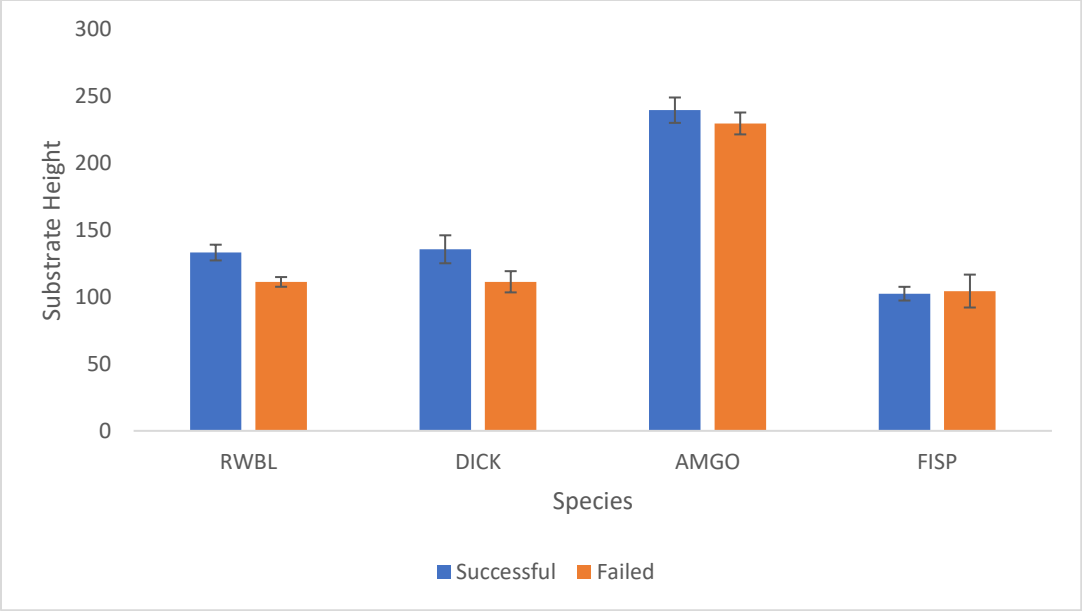

Figure 27. Substrate height of nest placement separated by successful (S) and failed (F) nests.

While the manipulation of nest height was not evenly spread between treatment groups, this experiment yielded notable results. A comparison of nest height showed that nest height was changed significantly in each group; nests that were manipulated differed significantly from their original height (Figure 33). An ANOVA comparison of the three groups showed that the height manipulation had a significant effect on nest height ($p = 0.0076$, log transformed = 0.004). The nest height of decreased nests was significantly different from control nests ($p = 0.0056$, log transformed = 0.0035), and raised nests did not have significantly different nest height from both control, and lowered nests. After excluding five control nests that could not be reached for a post-manipulation height comparison, there was a significant difference between the height of raised and lowered nest height ($p = 0.01$), and the comparison of lowered and control nest height approached significance ($p = 0.065$). Prior to treatment, there were no significant differences between groups, even when excluding control nests that could not be reached.

Table 12. Comparison of vegetation cover characteristics at successful and failed nests of the four most common species. Above and below concealment for AMGO nests only includes control nests.

Vegetation	**RWBL**		**t, p**	**DICK**		**t, p**	**AMGO**		**t, p**	**FISP**		**t, p**
Characteristic	**Success**	**Fail**		**Success**	**Fail**		**Success**	**Fail**		**Success**	**Fail**	
Bare Ground	37.076	23.96	1.87, 0.065	12.61	11.19	0.33, 0.74	17.89	14.09	0.74, 0.46	23	9.44	2.27, 0.043
Litter	61.29	73.3	-1.63, 0.11	77.07	79.05	-0.34, 0.74	73.13	72.61	0.086, 0.93	68.75	78.89	-1.32, 0.2
Forbs	67.24	65.42	0.23, 0.82	27.83	38.21	-1.11, 0.27	24.53	23.86	0.13, 0.9	62	54.17	0.59, 0.56
Grass	25.95	27.64	-0.38, 0.71	30	30.83	-0.14, 0.89	24.92	29.55	-1.01, 0.32	30	33.06	-0.26, 0.8
Wood	15.6	15.52	0.013, 0.99	70.54	59.4	1.01, 0.32	73.67	82.16	-1.54, 0.13	14.25	21.11	-0.56, 0.58
Dead Vegetation	19.66	17.97	0.88, 0.38	24.89	18.21	2, 0.053	28.67	27.61	0.21, 0.83	21.75	20	0.37, 0.72
LVH	99.79	91.22	1.41, 0.16	102.52	85.19	1.44, 0.16	182.31	179.73	0.19, 0.85	70.9	79.33	-0.87, 0.41
DVH	37.1	34	0.74, 0.46	47.35	43.29	0.65, 0.52	44.75	42.64	0.41, 0.69	46.3	35.67	1.22, 0.24
LD	2.52	2.57	-0.1, 0.92	3.3	2.77	1.11, 0.27	2.5	3.19	-1.56, 0.13	1.33	2.14	-1.69, 0.11
Visual Obstruction	6.14	6.3	-0.35, 0.73	6.39	5.87	0.66, 0.51	5.28	6.43	-1.45, 0.15	4.13	5.03	-1.39, 0.18
Above	69.45	73.87	-0.69, 0.49	78.15	77.98	0.02, 0.98	38.25	57.83	-1.55, 0.14	79.5	63.89	1.37, 0.19
Below	61.32	72.22	-1.66, 0.1	76.52	63.21	1.58, 0.12	49.75	62.5	-0.97, 0.34	28.5	39.44	-1.04, 0.31
Path	55	29.62	5.19, < 0.001	33.84	23.45	1.5, 0.14	46.17	38.52	0.88, 0.38	29.75	23.33	0.8, 0.43

Table 13. Individual variables and their effect on nest survival probability for red-winged blackbirds with a 1 unit increase in value. Z-score and model values are included for significance.

RWBL Variable	Effect/unit Increase (%)	z	Model
Nest Height	0.23	0.87	0.87
Substrate Height	1.8	0.031	0.023
Bare Ground	1.37	0.069	0.067
Litter	-1.14	0.11	0.11
Forbs	0.16	0.82	0.82
Grass	-0.47	0.7	0.7
Wood	0.01	0.99	0.99
Dead Vegetation	2.42	0.38	0.38
Live Vegetation Height	1.3	0.16	0.16
Dead Vegetation Height	0.93	0.46	0.46
Litter Depth	-1.21	0.92	0.92
Visual Obstruction	-4.2	0.72	0.72
Above Concealment	-0.54	0.49	0.49
Below Concealment	-1.25	0.1	0.1
Path	6.75	<0.001	<0.001
Lay Date	-0.9	0.58	0.58
Average Male Agitation	-2.5	0.9	0.9
Average Female Agitation	-47.16	0.026	0.015

Table 14. Individual variables and their effect on nest survival probability for dickcissel with a 1 unit increase in value. Z-score and model values are included for significance.

DICK Variable	Effect/unit increase (%)	z	Model
Nest Height	2.31	0.082	0.041
Substrate Height	1.4	0.075	0.056
Bare Ground	0.74	0.74	0.74
Litter	-0.55	0.73	0.73
Forbs	-1.12	0.27	0.26
Grass	-0.22	0.89	0.89
Wood	0.86	0.31	0.31
Dead Vegetation	6.02	0.069	0.046
Live Vegetation Height	1.21	0.17	0.14
Dead Vegetation Height	1.03	0.62	0.51
Litter Depth	24.8	0.27	0.26
Visual Obstruction	8.26	0.51	0.5
Above Concealment	0.027	0.98	0.98
Below Concealment	1.8	0.12	0.11
Path	2.14	0.15	0.13
Lay Date	1.4	0.3	0.29
Average Male Agitation	23.78	0.51	0.51
Average Female Agitation	36.01	0.37	0.37

Table 15. Individual variables and their effect on nest survival probability for field sparrow with a 1 unit increase in value. Z-score and model values are included for significance.

FISP Nest Variable	Effect/unit increase (%)	z	Model
Nest Height	-6.7	0.1	0.038
Substrate Height	-0.3	0.87	0.87
Bare Ground	15.32	0.11	0.015
Litter	-4.04	0.2	0.17
Forbs	1.05	0.54	0.54
Grass	-0.51	0.79	0.79
Wood	-1.06	0.56	0.56
Dead Vegetation	1.82	0.7	0.7
Live Vegetation Height	-2.4	0.38	0.34
Dead Vegetation Height	3.23	0.23	0.21
Litter Depth	-55	0.12	0.09
Visual Obstruction	-39.1	0.18	0.15
Above	2.69	0.18	0.17
Below	-2.32	0.31	0.28
Path	2.37	0.41	0.4
Lay Date	-5.56	0.059	0.017
Average Male Agitation	-19.37	0.72	0.71
Average Female Agitation	89.66	0.25	0.23

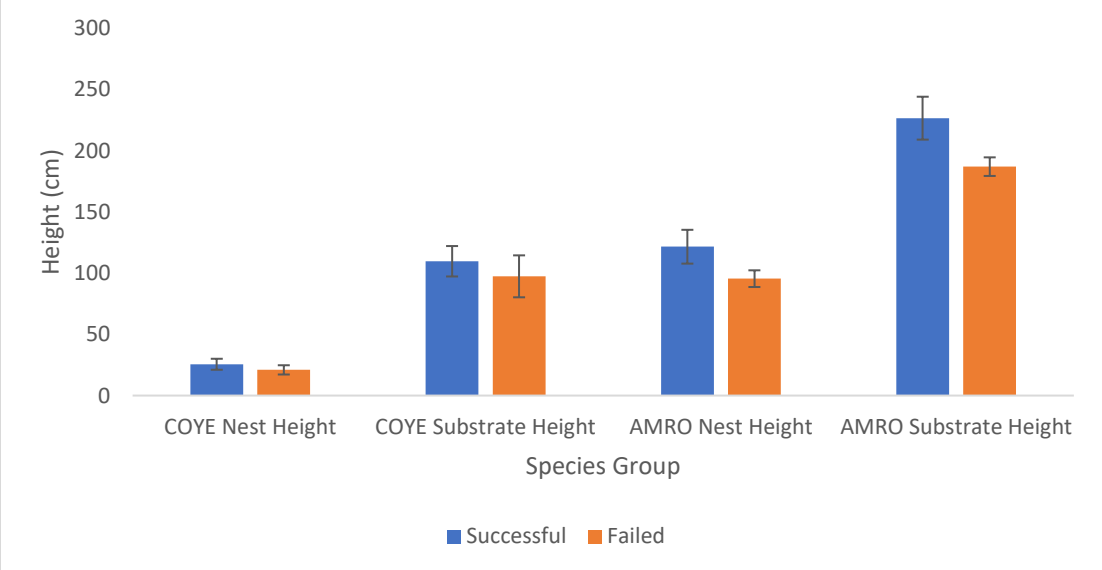

Figure 28. Common yellowthroat and American robin nest height and nest substrate height for successful and failed nests.

With changes in nest height, some concealment measurements changed. Nests with decreased height showed significantly more concealment from above once lowered ($p = 0.0060$) (Figure 34). There was also a significant decrease in the amount of concealment from below as the nest decreased in height ($p = 0.0064$) (Figure 35). Nests that increased in height resulted in significantly less cover from above ($p = 0.0037$), and an increase in concealment from below that approached significance ($p = 0.0503$).

Successful raised nests began with above and below concealment of 69.44% and 71.94% respectively. Post manipulation concealment was 48.61% and 77.5%, and the average concealment during monitoring was 56.76% and 75.33%. The two nests in the group that failed began at 85% and 37.5% from above, 62.5% and 97.5% from below, and failed at 85% and 15% from above and 85% and 97.5% from below. The average daily values were 56.25% concealed from above and 81.731% from below.

Successful lowered nests were discovered with above and below concealment of 47.12% and 80.77% respectively. Post-manipulation concealment was 69.04% and 62.69%, and the average concealment for monitoring was 61.37% and 69.02%. The five failed nests that were lowered began with above and below concealment of 64% and 71% and failed with above concealment of 80.5% and the same 71% from below, as no nest increased or decreased concealment enough to change cover class categories.

Table 16. Comparison of vegetation cover characteristics at both successful and failed common yellowthroat and American robin nests.

Vegetation	**COYE**				**AMRO**			
Characteristic	**Successful**	**SE**	**Failed**	**SE**	**Successful**	**SE**	**Failed**	**SE**
Bare Ground	16.07	5.92	5	2.5	12	6.82	17.5	7.29
Litter	75	7.01	76	5.51	71	9.44	59.38	16.94
Forbs	29.64	7.61	43	17.15	43	8.96	38.13	16.5
Grass	26.43	7.73	34	11.64	19.5	4.5	20.63	5.63
Wood	14.64	8.28	14.5	12	92.5	3.06	85.63	8.25
Dead Vegetation	28.21	6.98	38	7.52	19.5	4.5	15	0
LVH	77.29	16.12	54.4	11.16	183.4	20.47	137	17.16
DVH	48.71	8.16	69.4	17.72	45	10.09	35	8.5
LD	1.82	0.6	2.45	0.22	3	0.97	2.38	1.01
RP	5.54	1.01	4.35	0.95	7.85	0.9	4.94	0.89
Above	60	15.35	73.5	10.62	71	13.87	79.38	14.27
Below	22.86	11.38	15	0	85.5	12	70.63	18.77
Path	45	9.91	47.5	15.85	54.5	15.68	32.5	11.32

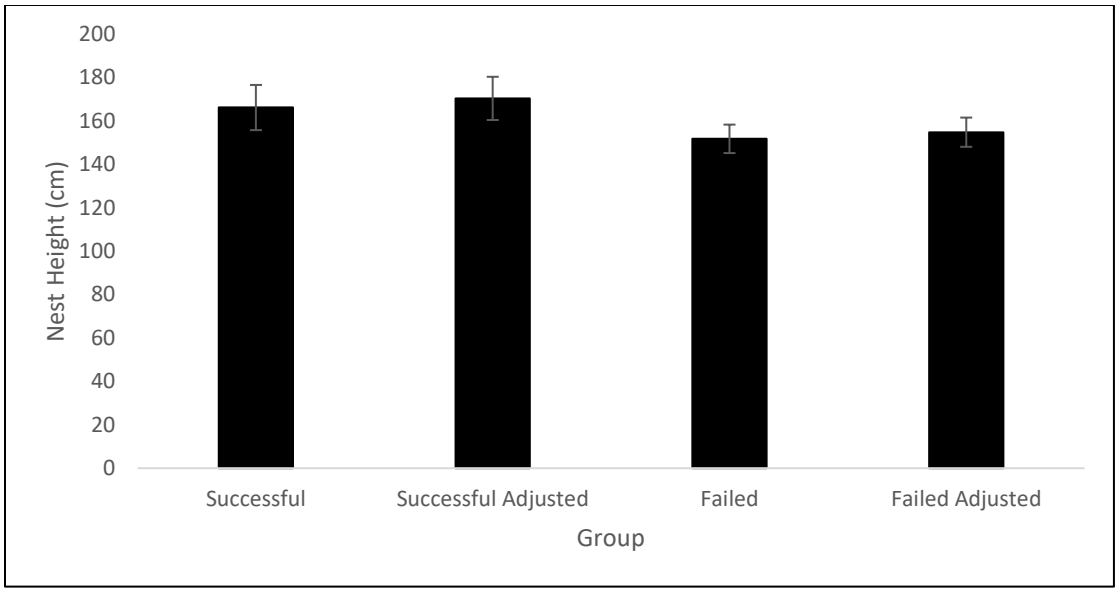

Figure 29. Comparison of AMGO nest height at time of nest fate, and adjusted nest height accounting for height manipulation and exposure days.

Table 17. Comparison of American goldfinch nest height of manipulation groups.

Treatment	Mean Change In height (cm)	Range (cm)	SD	SE
Increased Height	15.91	9 to 27	16.63	3.82
Decreased Height	-28.37	-67 to -9	4.83	1.46

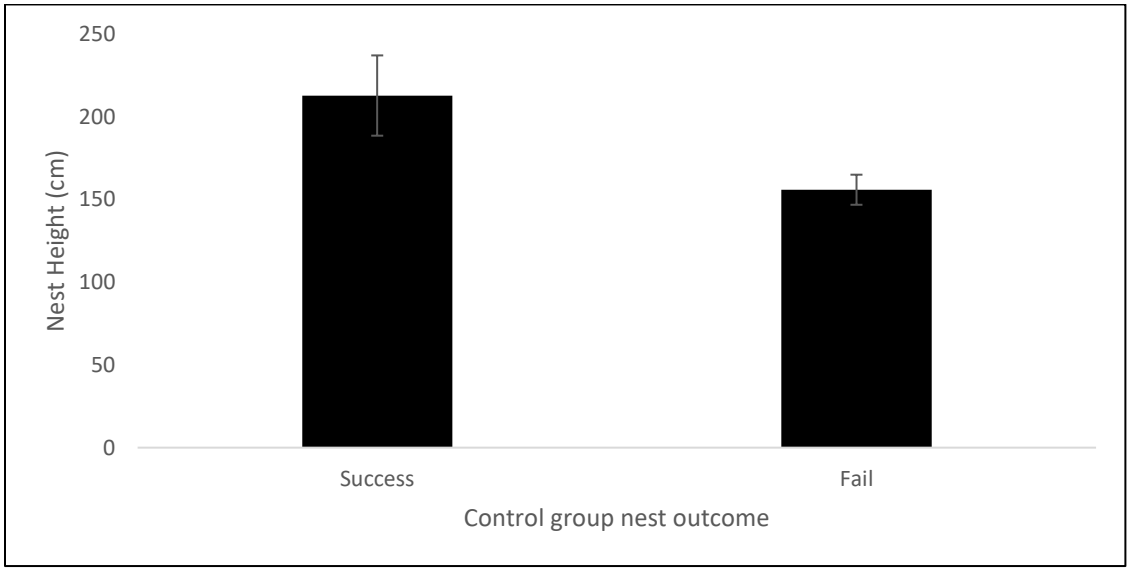

Figure 30. Nest height of unmoved, control AMGO nests grouped by nest outcome.

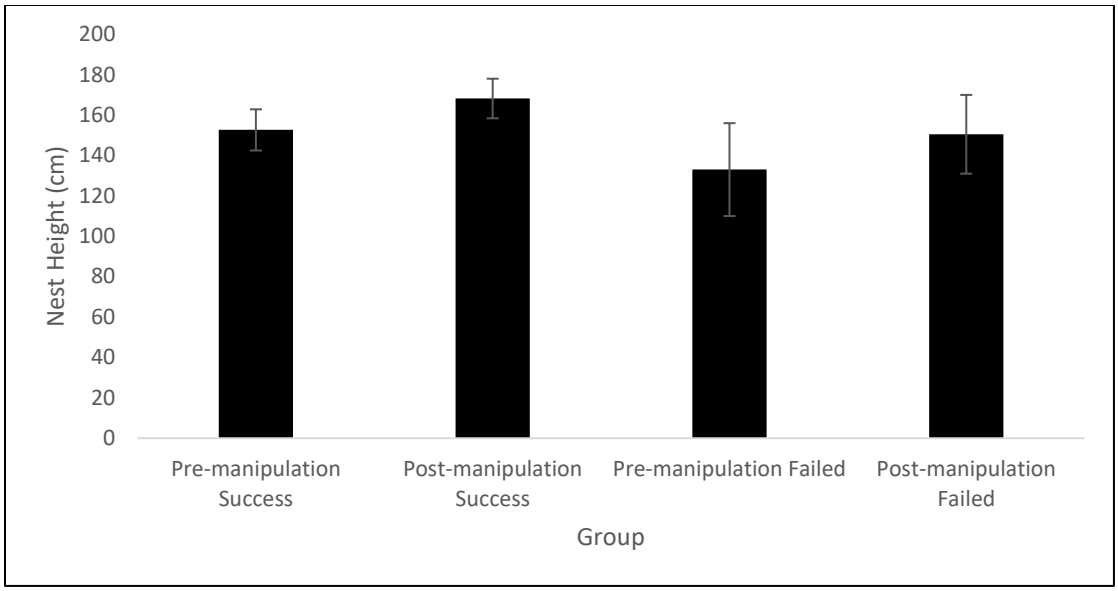

Figure 31. Nest height of raised AMGO nests separated by nest fate and pre- and post-manipulation nest height.

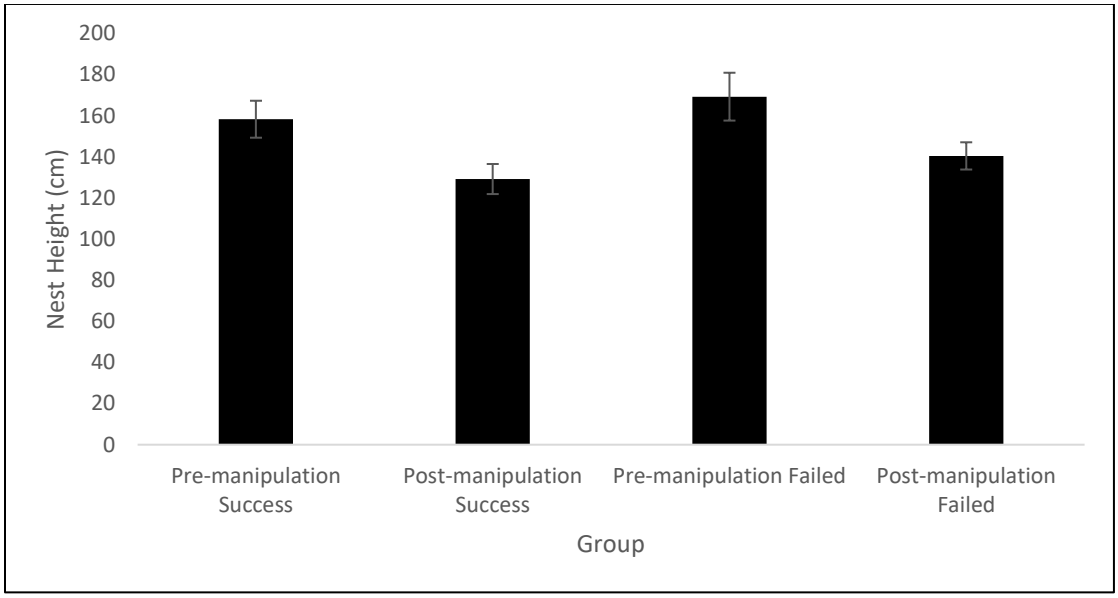

Figure 32. Nest height of lowered AMGO nests separated by nest fate and pre- and post-manipulation nest height.

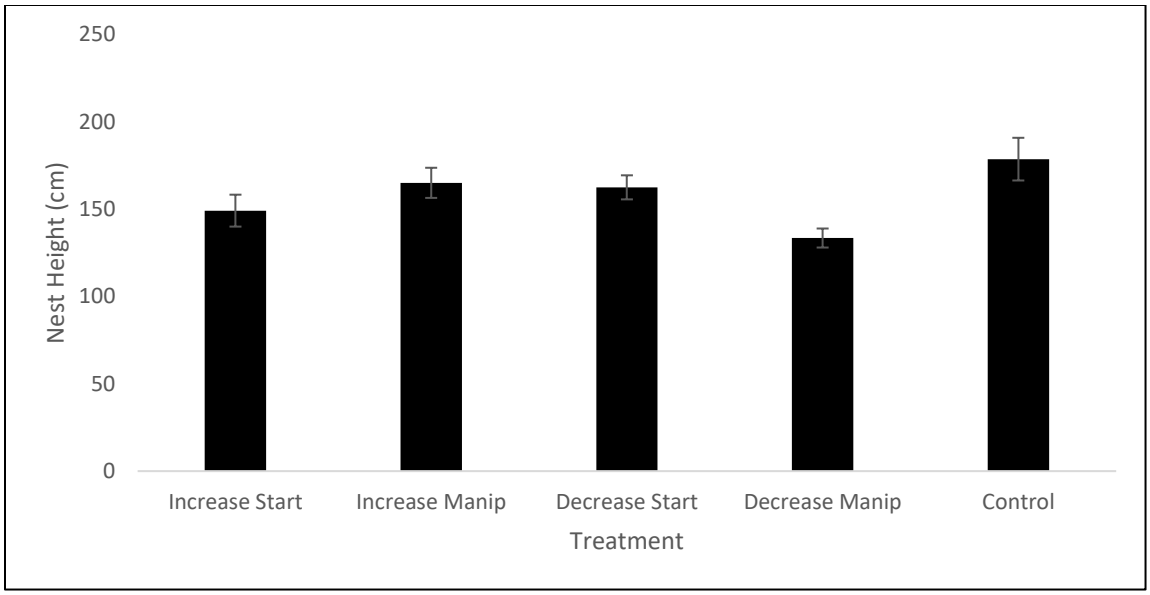

Figure 33. Nest height of AMGO nests before and after height manipulation.

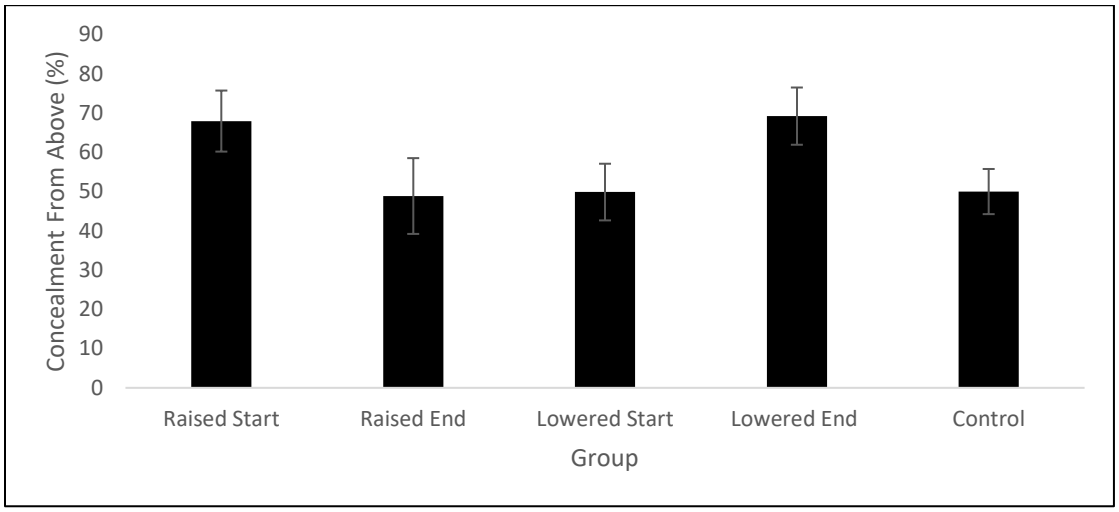

Figure 34. Concealment from above at AMGO nests before and after height manipulation.

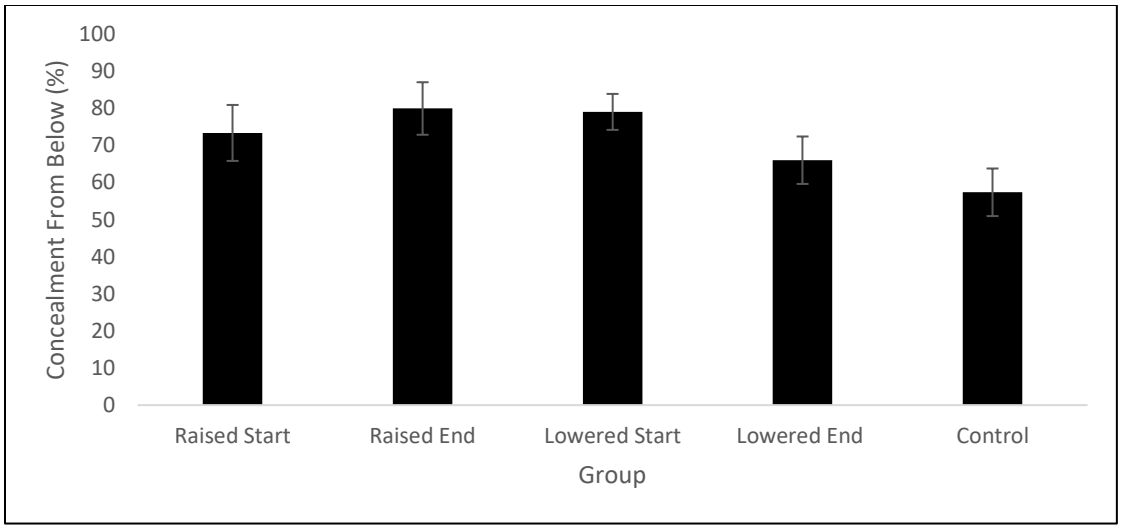

Figure 35. Concealment from below AMGO nests before and after height manipulation.

Logistic regression of American goldfinch nest site characteristics yielded few significant effects on survival probability (Table 18). Non-significant but notable predictors for survival probability included grass and wood cover, and visual obstruction. For the 25 control nests, there was a significant increase in survival probability of 2.05% for every 1 cm increase in nest height ($p = 0.043$). Control nests that had simulated manipulation had a 0.29% increase in survival with a 1 cm nest height increase. Excluding the 5 unreachable nests, control nests had a 1.83% increase of survival probability with a 1 cm increase in nest height. For nests that were raised, while not significant, the starting nest height carried a 2.56% increase in survival, and the resulting nest height was 2.47%. The actual change in height, in centimeters, lowered survival by 8.1% for every 1 cm increase in manipulated height. For lowered nests, the starting nest height had a 1.3% negative effect on survival, the post-manipulation height resulted in a survival decrease of 2.2% for every 1 cm addition, and the actual change in height showed a small increase of 0.03%. By adding the pre- and post-manipulation nest heights for each manipulated group, the resulting nest height carried a decrease in survival

probability for every 1 cm increase of nest height. At raised nests, the pre-manipulation survival probability was 6.4% and post-manipulation was -3.9%. For lowered nests, pre-manipulation was 0.4% and post-manipulation was –2.6% and neither of these were significant.

For manipulated nests, concealment from above and below was evaluated separately both prior to and after manipulation, and by adding the two values to see how they affected survival probability. At raised nests, survival probability always decreased with post-manipulation increases in concealment from both directions. This was true when comparing each direction separately, adding above and below concealment, and adding pre- and post-manipulated above or below concealment. At lowered nests, survival increased slightly after manipulation for increased concealment from above, but both negatively affected survival with the increase. Prior to manipulation, increased concealment from below increased survival, and then decreased survival once nests were lowered. The addition of post-manipulation concealment from below was a significant variable to a model with pre-manipulation concealment from below ($p = 0.012$).

Parental presence at nest

Red-winged blackbird

There was a significant difference between average male and female response at all nests, successful nests, and failed nests (Table 19). Males were usually more often present at nests than females (Tables 20-24). Males were significantly more aggressive toward my presence than females. Males were more aggressive at successful nests, which approached a significant difference ($p = 0.064$), and there was no significant difference at nests of each fate for female aggression ($p = 0.31$).

Table 18. Individual variables and their effect on nest survival for American goldfinch with a 1 unit increase in value. Z-score and model values are included for significance.

AMGO All Nests Variable	Effect/unit increase (%)	z	Model
Original Nest height	0.86	0.21	0.18
Final Nest height	0.66	0.3	0.27
Change In Nest height	-0.61	0.68	0.67
Substrate Height	0.46	0.45	0.44
Bare Ground	1.2	0.46	0.45
Litter	0.12	0.93	0.93
Forbs	0.19	0.9	0.9
Grass	-1.71	0.31	0.31
Wood	-2.32	0.14	0.12
Dead Vegetation	0.34	0.83	0.83
Live Vegetation Height	0.11	0.85	0.85
Dead Vegetation Height	0.63	0.68	0.68
Litter Depth	-24	0.13	0.12
Visual Obstruction	-13.11	0.16	0.15
Original Concealment From Above	-0.81	0.4	0.4
Final Concealment From Above	-0.7	0.45	0.45
Original Concealment From Below	0.32	0.74	0.74
Final Concealment From Below	-0.48	0.61	0.61
Path	0.81	0.38	0.37
Lay Date	-1.5	0.49	0.49
Average Male Anger	65.03	0.43	0.37
Average Female Anger	2.84	0.94	0.94

There was a significant positive relationship between male and female aggression at nests ($r = 0.42$, $t = 4.42$, $df = 89$, $p < 0.001$). There were no significant correlations between nest height and aggression at different stages, or overall. The amount of above- or below-nest concealment was not a predictor for red-winged blackbird aggression.

Dickcissel

On average, female dickcissels were more aggressive than males at all nests, successful, and failed nests. For each sex and nest fate, males did not exhibit a significantly different amount of aggression ($p = 0.45$). Similarly, females exhibited non-significant difference between successful and failed nests ($p = 0.37$). There were no significant relationships between nest height and either overall anger of each sex, or anger at different stages of the nesting cycle. Male and female anger were positively

correlated ($r = 0.45$, $t = 3.35$, $df = 44$, $p = 0.0017$) and levels of aggression was not significantly or notably correlated to either above- or below-nest concealment.

American goldfinch

Despite low aggression from both sexes, female American goldfinch aggression was significantly higher than males at all nests, successful nests, and failed nests. Male aggression did not differ significantly between nest fates ($p = 0.12$), and female aggression at successful nests approached a significant difference ($p = 0.062$) from failed nests. There was a significant positive relationship between male and female American goldfinch aggression ($r = 0.70$, $df = 52$, $p < 0.001$). Using the control group, average adult aggression was negatively correlated with concealment from above, and positively correlated with concealment from below.

A comparison of the three most common species showed a significant effect of species on average male aggression. American goldfinch and dickcissel average male aggression did not differ significantly ($p = 0.17$), but red-winged blackbird male aggression differed significantly from both goldfinch and dickcissel ($p = 0$ for both). The model R^2 was 0.36, and was significant ($p < 0.001$). In the model, American goldfinch ($p=0.031$) and red-winged blackbird ($p < 0.001$) aggression were significant, and dickcissel approached significance ($p = 0.07$). For female aggression, species effect approached significance ($p=0.062$), and none of the species differed from each other significantly. The dickcissel-American goldfinch interaction was most robust ($p=0.061$). The R^2 was very small (0.029), and the goldfinch intercept (0.90, $p < 0.001$) and dickcissel intercept (0.41, $p = 0.02$) were significant, while red-winged blackbird (0.28, $p = 0.076$) approached significance.

Field sparrow

Despite the low number of nests, field sparrow aggression comparisons were performed due to the near-equal distribution of successful and failed nests. Female field sparrows were significantly more aggressive than males at all nests, successful nests, and failed nests. At failed nests, males were more vocal than at successful nests, not seen in other species I monitored. The difference in vocalization by sex approached significance ($p = 0.083$) at failed nests. The difference in male vocalization at nests of each fate was not significant ($p = 0.73$) and was closer to significance for females, but still far from 0.05 ($p = 0.26$).

Common yellowthroat and American robin each showed differences between sexes, despite their small sample sizes (Table 25). Females were always more vocal at nests, and male robins were never detected.

Female Flush

As I approached nests or found them for the first time, I recorded flushing activity from the nest, the distance I was from the nest at the time of the event, and in many cases the time of the event. As a species, the average distance from my approach for red-winged blackbird females was 3.9 m ($n = 34$) (Figure 36). Dickcissel flushed 2.15 m from my approach ($n = 34$). American goldfinch flushed an average of just over 3.02 m from my approach ($n = 38$). There was a significant effect of species on flush distance for the three most sampled species ($p < 0.001$), and each species was significantly different from each other. Field sparrow distance was 2.26 m before flushing ($n = 15$), yellowthroat 2.19 m ($n = 10$), and robin 3.33 m ($n = 7$).

Table 19. Male and female aggression level comparisons for the four major species monitored, separated to compare all nests, and successful and failed nests.

	RWBL			DICK			AMGO			FISP		
Group	Male	Female	t, p	Male	Female	t, p	Male	Female	t, p	Male	Female	t, p
All Nests	1.84	1.17	3.32, < 0.001	0.63	1.31	-0.35, < 0.001	0.28	0.9	-4.52, < 0.001	0.37	1.61	-4.38, < 0.001
Successful	2.15	1.32	3.25, 0.0019	0.74	1.43	-2.44, 0.019	0.38	1.09	-3.5, < 0.001	0.31	1.84	-4.92, < 0.001
Failed	1.7	1.12	2.87, 0.0049	0.52	1.19	-2.53, 0.015	0.15	0.67	-3.33, 0.0023	0.44	1.35	-1.85, 0.083

American robin females were most likely to flush from the nest as they were present at over 50% of nest checks (Table 26). Very few flush events were recorded during the build stage for the major species. Females were usually more likely to be on a nest during the incubation stage than the nestling stage.

Table 20. Male and female presence during nest checks for all stages.

All Checks	Presence	Checks	%
Male RWBL	233	406	57.39
Female RWBL	170	406	41.87
Male DICK	36	172	20.93
Female DICK	102	172	59.3
Male AMGO	36	325	11.08
Female AMGO	178	325	54.77
Male FISP	5	64	7.81
Female FISP	45	64	70.31
Male COYE	4	55	7.27
Female COYE	37	55	67.27
Male AMRO	0	44	0
Female AMRO	30	44	68.18

Table 21. Male and female presence during nest checks for the nest building stage.

Build stage	Presence	Checks	%
Male RWBL	4	26	15.38
Female RWBL	1	26	3.85
Male DICK	0	4	0
Female DICK	0	4	0
Male AMGO	3	36	8.33
Female AMGO	8	36	22.22
Male FISP	0	1	0
Female FISP	1	1	100
Male COYE	0	1	0
Female COYE	0	1	0
Male AMRO	0	3	0
Female AMRO	0	3	0

Table 22. Male and female presence during nest checks for the egg laying stage.

Lay stage	Presence	Checks	%
Male RWBL	12	35	0.342857
Female RWBL	14	35	40
Male DICK	2	21	0.095238
Female DICK	8	21	0.380952
Male AMGO	1	38	0.026316
Female AMGO	23	38	0.605263
Male FISP	0	3	0
Female FISP	1	3	33.33
Male COYE	0	6	0
Female COYE	3	6	50
Male AMRO	0	4	0
Female AMRO	2	4	50

Table 23. Male and female presence during nest checks for the incubation stage.

Incubation	Presence	Checks	%
Male RWBL	147	234	0.628205
Female RWBL	104	234	0.444444
Male DICK	17	91	0.186813
Female DICK	60	91	0.659341
Male AMGO	11	113	0.097345
Female AMGO	79	113	0.699115
Male FISP	3	32	0.09375
Female FISP	20	32	62.5
Male COYE	3	29	0.103448
Female COYE	18	29	0.62069
Male AMRO	0	19	0
Female AMRO	11	19	0.578947

Table 24. Male and female presence during nest checks for the nestling stage.

Nestling	Presence	Checks	%
Male RWBL	70	111	0.630631
Female RWBL	51	111	0.459459
Male DICK	17	56	0.303571
Female DICK	34	56	0.607143
Male AMGO	22	138	0.15942
Female AMGO	68	138	0.492754
Male FISP	2	28	0.071429
Female FISP	23	28	0.821429
Male COYE	1	19	0.052632
Female COYE	16	19	0.842105
Male AMRO	0	18	0
Female AMRO	16	18	0.888889

Table 25. Male and female aggression level comparisons for common yellowthroat and American robin, separated to compare all nests, and successful and failed nests.

	COYE				AMRO			
Group	Male	SE	Female	SE	Male	SE	Female	SE
All Nests	0.17	0.07	1.33	0.15	0	0	1.64	0.25
Successful	0.29	0.11	1.46	0.14	0	0	2.11	0.17
Failed	0	0	1.13	0.3	0	0	1.05	0.36

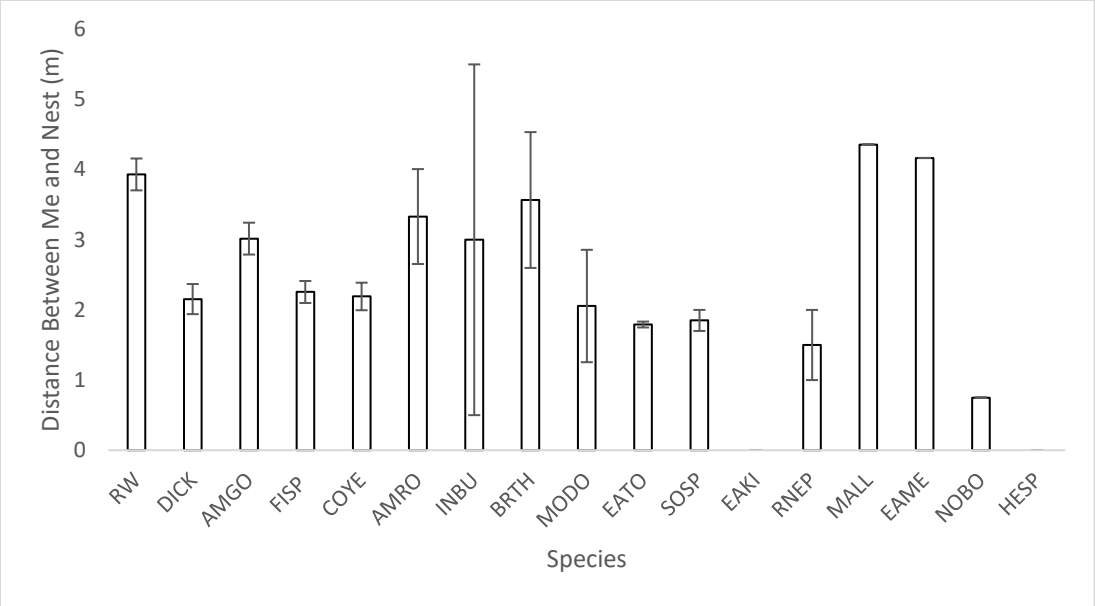

Figure 36. Average flush distance between my approach of a nest and the moment a female flushed from the nest.

Trail Cameras

Trail cameras captured 6918 pictures and videos (Tables 27-30); 4303 (62.2%) were taken at 13 nest sites comprising of approximately 31 days of capturing. The remaining 2615 (37.8%) were captured from game trails or field-forest edges, comprising approximately 28 days of capturing. Five red-winged blackbird, two field sparrows and dickcissels, and one American goldfinch, indigo bunting, eastern meadowlark and common yellowthroat nest were selected for camera placement. 10 additional placements were on deer trails or at edges where animal movement should have been high. This attempted to capture possible nest predators within the property.

Table 26. Female flush occurrences overall and separated by stage.

Species	TOT	%	Build Flush	%	Lay Flush	%	Incubation Flush	%	Nestling Flush	%
RWBL	50/406	12.32	0/26	0	5/35	14.29	37/234	15.81	8/111	7.21
DICK	58/172	33.72	0/4	0	5/21	23.81	42/91	46.15	11/56	19.64
AMGO	106/325	32.62	5/36	13.89	18/38	47.37	57/113	50.44	26/138	18.84
FISP	28/64	43.75	0/1	0	1/3	33.33	14/32	43.75	13/28	46.43
COYE	22/55	40	0/1	0	3/6	50	14/29	48.28	5/19	26.32
AMRO	24/44	54.55	0/3	0	2/4	50	9/19	47.37	13/18	72.22

Almost 90% of the 4303 nest site pictures were triggered by either moving vegetation or animals not in frame, with the remaining majority being the nesting species, followed by deer. One nest, a field sparrow, was predated while having a camera positioned on it. An overexposed blur one night was followed the next night with a deer repeatedly lowering its head into the nest area. Either of these events or an unrecorded encounter resulted in the predation.

At the non-nest sites, almost 87.5% were either triggered by moving vegetation or animals not in frame. Most of the remaining pictures, almost 9%, were of deer. Some potential nest predators were recorded, including raccoons, coyote and opossum.

Table 27. Overall trail camera captures at all sites separated by what was captured.

Capture	All Pictures	Nest Only	Non-nest Only
Nothing	6130	3843	2287
Deer	321	86	235
RWBL	218	218	0
COYE	130	130	0
Insect	31	11	20
Human	16	0	16
Opossum	13	0	13
Unidentified	12	7	5
Passerine	12	2	10
Raccoon	10	0	10
Squirrel	8	0	8
Small rodent	5	0	5
FISP	4	4	0
Coyote	3	0	3
DICK	2	2	0
Domestic dog	1	0	1
Rabbit	1	0	1
Pheasant	1	0	1
Total	6918	4303	2615

Table 28. Non-nest site trail camera captures by site, separated by what was captured.

Non-nest Cameras	Total	Burrus	Hindsboro	Closson
Nothing	2287	114	952	1221
Deer	235	166	26	43
Human	16	0	4	12
Opossum	13	0	5	8
Flying Insect	11	0	0	11
Passerine	10	0	0	10
Raccoon	10	5	0	5
Insect	9	0	9	0
Squirrel	8	0	0	8
Rodent	5	0	5	0
Unidentified	5	3	0	2
Coyote	3	0	1	2
Domestic dog	1	0	1	0
Rabbit	1	0	1	0
Pheasant	1	0	0	1
Total	2615	288	1004	1323

Table 29. Individual nests with trail cameras, associated sites, captures, and the number of days with cameras.

Nest Monitored	Field	Captures	Days	Nest Monitored	Field	Captures	Days
AMGO	Hindsboro	84	5	EAME	Closson	95	2
FISP	Burrus	5	1	RWBL	Closson	1227	4
FISP	Burrus	29	2	RWBL	Closson	708	2
DICK	Burrus	10	1	DICK	Closson	440	4
COYE	Burrus	161	2	RWBL	Closson	1597	4
Total	Burrus	205	6	INBU	Closson	8	1
				RWBL	Closson	35	2
				RWBL	Closson	5	1
				Total	Closson	4115	20

Table 30. Captures at nest sites by site.

Nest Capture	Total	Burrus	Hindsboro	Closson
Nothing	3843	56	11	3776
RWBL	218	0	0	218
COYE	203	130	73	0
Deer	13	13	0	0
Insect	11	0	0	11
Unidentified	7	2	0	5
FISP	4	4	0	0
DICK	2	0	0	2
Passerine	2	0	0	2
TOT	4303	205	84	4014

Bi-weekly Vegetation Surveys

Bare ground and litter cover rarely changed much, and only significantly changed after a burn event or mowing. Any characteristic involving active growing was usually showed significant differences from one period to the next. Litter depth slowly accumulated over time, unless burning or mowing occurred. In 2015, all sites showed a significant effect of time on live and dead vegetation height, litter depth, and visual obstruction. Time had a significant effect on grass and forb cover at Douglas-Hart, Burrus NW & SW, and Closson SE & NW. Grass cover was significantly affected at Closson NW, and forb cover at Hindsboro.

In 2016, time had a significant effect on grass, forb, and dead vegetation cover, live and dead vegetation height, litter depth (except Closson NE), and visual obstruction. Additionally, time had a significant effect on bare ground at Hindsboro, and Closson SE, SW, and NE. There was a significant effect on litter cover at Hindsboro, and all four Closson plots. The only site where woody vegetation cover was affected significantly by time was Burrus SE.

Discussion

Survival

Red-winged blackbirds were widespread on the study sites, although most nests were found at Closson. Red-winged blackbirds were the most abundant species in Iowa CRP fields (Patterson & Best 1996) and in agriculture conservation buffers (Adams et al. 2013). This species is a habitat generalist and can utilize resources of many cover types, and had high survival in my study. Apparent nest survival for my study was 38 % as 32 of 87 nests fledged. This was higher than Patterson & Best's (1996) recording in Iowa CRP (26%), and the 15.9% success in Mississippi found by Conover et al. (2011). In West Virginia, Warren & Anderson (2005) recorded 21% nest success in Canaan Valley NWR grasslands. Linz et al. (2014) recorded survival of 23% & 29% for two study groups in North Dakota wetlands.

My monitored nests had a survival probability of 23.88%, higher than what Kershner & Bollinger (1996) calculated at 6% for a small number of nests on Illinois airports, and Davison & Bollinger (2000) found 20% survival in Coles County. Conover et al. (2011) estimated 8.6% red-winged blackbird survival in agriculture areas whereas Adams et al. (2013) estimated red-winged blackbird survival of 35%. In Pennsylvania, Murray (2015) estimated a DSR of 97.1% and an overall success of 48%. This is higher than my study and may be due to Murray (2015) having ten nests, with 6 succeeding. Yasukawa (2016) recorded 56% predation on over 550 nests, with no differences between incubation and nestling stage predation. My daily survival during the nestling stage was almost 4% higher than incubation, and the resulting survival probability was

23% higher for nests with nestlings. Red-winged blackbird survival seems to be highly variable depending on region and sample sizes.

Dickcissel apparent nest success was 50%, which was higher than other studies. Patterson & Best (1996) found survival to be 23% for 39 nests, Frawley (1989) found 0.6% survival in alfalfa fields, and Conkling et al. (2015) had 4.9% - 14.2% success in Mississippi. Walk et al. (2004) recorded 12/37 dickcissel nests fledging, and 8/18 replacement nests fledging. Klug et al. (2010) had 13 dickcissel nests fledge of 33 monitored in Kansas. My results more mirror the 43% success found in the same Illinois region by Davison & Bollinger (2000). Conover et al. (2011) estimated 22.9% dickcissel success in agricultural areas, near my 27.66% estimate. In Missouri, Jaster et al. (2014) had a DSR of 94.7 for dickcissel, and a 26.7% survival probability. This is comparable to my 94.9% DSR and 27.66% survival probability. Adams et al. (2013) estimated dickcissel survival of 44.8% using a May 1 initiation date, and at peak initiation the success estimate was 29.7%. My earliest estimated nest initiation was May 12, and most nests were initiated in June and few in July. Lay date in my study carried a 1.4% increase in survival with each day after May 1st. As a grassland obligate species, continued nest success data is imperative for tracking this species' reproductive success.

Due to the late breeding season of American goldfinches, Schmidt (2003) excluded the species from his study. Peak (2003) recorded 66% of nests failing, with a 37% chance of surviving the nesting period, and nests with more concealment from above were more prone to predation. Control nests that failed in my study had more concealment than successful nests from above and below, although the difference was not significant. Watt & Dimberio (1990) recorded survival of goldfinch nests from 60-83%.

Middleton (1979) found survival rates from 34%-77.8% for goldfinches and McCoy et al. (1999) found 66.5% success in Missouri, whereas other grassland birds ranged in success from 19-41.5%. Overall goldfinch success was high in my study, with 59% fledging, and 46% of the remaining bird community nests succeeded. Of the 30 manipulated nests, 22 (75%) fledged, echoing other high survival numbers from previous studies. While my manipulation groups were not perfectly even, fewer raised nests failed than lowered nests. This may be due to increased sample size, or increased predation pressure from lower nests with altered concealment. Having cameras continuously on nests would aid in determining if the changes in nest height led to different predation pressures.

Davison & Bollinger (2000) found 39% success for field sparrows. Just over half of my field sparrow nests succeeded, not far from their findings with my small sample size. Common yellowthroat apparent success was 58.3%, higher than the 41% Murray and Best (2014) found in Iowa. Actual ground nesting birds like the ring-necked pheasant, northern bobwhite, mourning dove and eastern meadowlark had low detection and variable survival. One of two pheasant nests survived. Patterson & Best (1996) found 65% survival for ring-necked pheasants. All three of my mourning dove nests fledged. Magee et al. (2011) found 6 mourning dove nests in Colorado sagebrush, with 5 succeeding. The single northern bobwhite nest fledged at Burrus. Northern bobwhite is a well-studied bird with nest success between 40-50% in Georgia (Staller et al. 2005), and Texas (Rader et al. 2007). Potter et al. (2011) found survival rates for bobwhites of 27-49%.

Eastern meadowlark survival can be high in grasslands, as Warren & Anderson (2005) recorded 70%, and Davison and Bollinger (2000) found 32% success in the same region as my study. In Illinois airports, where mowing can be hazardous, 14% of meadowlark nests were calculated to succeed (Kershner & Bollinger 1996). Mowing mortality was more prominent than predation in their study. I suspect the meadowlark nest at Closson failed due to a mowing event, emphasizing proper timing either before or after the breeding season.

One of two song sparrow nests fledged during my study. Song sparrow success was calculated as 44% at Illinois airports (Kershner & Bollinger 1996). Chase (2002) had high success for California song sparrows, as 43% survived. Only one indigo bunting nest succeeded of the four I monitored. In South Carolina, Weldon & Haddad (2005) had a failure rate of 83.6% for over 100 nests. The single mallard nest I monitored may have been representative of the local population, as very few individuals were seen on the water. In Iowa, Koford et al. (2016) recorded 15% of nests succeeding and mallards in the prairie pothole region of Canada had DSR of 93.8 and 20% survival probability (Mcpherson et al. 2003). Artman et al. (2001) found 85% nest success in North Dakota grasslands and croplands in nest structures.

I monitored two eastern kingbird nests; one each fledged and failed. Murphy (1983) found kingbird survival of 57% and 37% in New York and Kansas respectively. Cancellieri & Murphy (2014) recorded 36% survival of kingbird nests, in addition to 13/33 succeeding in artificially placed nests that kingbirds chose to nest in. The Henslow's sparrow nest I monitored fledged; Jaster et al. (2014) calculated an overall survival probability of 56% for the species in Missouri, and Ribic et al. (2012) recorded

39% survival. Anderson and Chadbourne (2015) recorded 5/8 successful American robin nests, and a survival probability of 31%, close to my 34% survival probability with less than 10 extra exposure days than their study.

Bleho's (2014) meta-analysis of 18 Canadian grassland studies relating to cattle effects found 53% of nests failed and 38% succeeded, and almost 90% of losses were due to predation. My sample size was much smaller, as it was only one study, but the near-50% success I had was promising. Klug et al. (2010) found apparent survival of their dickcissel, sparrow, and eastern meadowlark nests was 29.7%. Vickery et al. (1992) recorded grassland community nest survival of 42%, Henningsen and Best (2005) recorded 27% success in a grassland community and Klug et al. (2010) found 29.7% overall success in Kansas, with DSR of 91.5 and a survival probability of 16.8%. Grassland bird community survival seems to vary by region, and even by state, so site specific studies like mine will be important for adding to trends across the country. Shew et al. (2019) recorded 31% survival for the grassland bird community in northwest Illinois CRP propertied, with red-winged blackbirds accounting for over half of the nests, similar to my observations of red-winged blackbird nest abundance. Within the tallgrass prairie biome, Shochat et al. (2005) recorded 28% nest success in Oklahoma, while 65.8% failed. Over 75% of failures were due to predation. Very few nest losses in my study were not due to predation, as a handful were abandoned, and possibly one or two losses were weather related.

Taller substrate generally meant higher nests for the grassland bird community in my study. This was especially true if they were selecting trees and shrubs as nesting substrate. Dickcissel occasionally chose woody vegetation to nest in, and since this is a

grassland obligate species, supports the importance of some woody vegetation within managed grassland sites. Along with nest height was the significant amount of woody vegetation cover at nest sites compared to random sites, as the most sampled species were selecting nests in woody vegetation. Species like common yellowthroat and field sparrow selected short vegetation with associated nests close to the ground, with little vegetation concealing the nest from below.

Nesting on the ground vs. above-ground has resulted in mixed outcomes in other studies. Patterson & Best (1996) found that ground nesting survival was twice as high as those above ground, and Pietz & Granfors (2000) found higher survival for ground nesters. Davison and Bollinger (2000) did not find differences between ground and above-ground nest success. Schmidt (2003) found that nests under 25cm were most vulnerable to raccoon predation. Shochat et al. (2005) recorded higher nest success of nests built in trees, when compared to either ground or shrub nests, and that success increased with nest substrate height, not nest height.

My logistic regression supported this, as every centimeter increase of nest height for red-winged blackbird increased survival by 0.2% and a 1 cm increase in substrate height increased survival by 1.8%.

Dickcissels in my study had a 2.31% survival probability increase with a 1cm increase in nest height, and 1.4% increase with substrate height. Nest height for goldfinches carried a 0.86% increase in survival probability, and substrate height 0.66% for every 1 cm increase. A 1 cm increase in nest height led to a stark drop in survival of -6.7% for field sparrows, with substrate height being slightly negative at -0.3%. Ground nesters were less common in my study, and while survival was high, there will still

predation losses with the small sample sizes, although successful common yellowthroat nests were higher, and failed field sparrow nests were higher than successful ones.

Habitat buffers studied by Conover et al. (2011) found red-winged blackbird average nest height from 84-100 cm, and dickcissel nest height averaged 50-57 cm. My average red-winged blackbird nest height was much lower, while fairly similar for dickcissels. Conover et al. (2011) in another publication, found a red-winged blackbird nest height range of 65.9-89.3cm, closer to my low 60 cm average, indicating that substrate choices may affect overall nest height for this species, as I found them nesting in both forbs and woody vegetation. Patterson & Best (1996) recorded average red-winged blackbird nest height of 44 cm, and dickcissel nest height of 38 cm in Iowa CRP fields. Lituma et al. (2012) recorded dickcissel nest heights of 38 cm in restored Texas prairie and 15 cm in exotic grass prairie. These numbers were much lower than my average for dickcissel, since most nested in woody vegetation, but some individuals were within the exotic grass range of Lituma et al. (2012) by nesting in brome, alfalfa, or young trees. The substrate height in their study was an average of 118 cm in restored habitat and 46.5 cm in grasses. As a species, average dickcissel nesting substrate was 126 cm in my study, similar to Lituma et al. (2012) in restored sites. Walk et al. (2004) found no significant differences between successful and failed dickcissel nest height, and the surrounding vegetation at the nest sites were not significantly different either. While my study found an almost 20 cm difference in dickcissel nest height between successful and failed nests, the difference was just outside $p = 0.05$. Dickcissel vegetation structure was not significantly different at my nests when comparing successful and failed nests, meaning potential confounding factors or non-significant interactions may affect nest

success. Dickcissels at my Illinois sites seemed to be drawn to the woody vegetation, which I presume is the reason for increased nest height as the two were significantly positively correlated, and nest height was moderately positively associated with woody vegetation cover ($r = 0.40$, $r = 0.006$).

Chase (2002) studied song sparrows in scrub habitat in California, and recorded nest height of 50-65 cm due to shrub nesting. Saunders et al. (2003) also had higher song sparrow nests, ranging an average of 40-50cm in British Columbia. The two song sparrow nests I found had nest heights of 9 cm on roadside grass and 15cm in yellow coneflower (*Ratibida pinnata*) stalks. This lends more insight to the variability of song sparrow nest site selection. Eastern kingbird nest height of this species can vary due to its affinity for trees. My two nests were 1.37 m and 1.34 m high, which is far from the 6.5 m and 7.1 m averages from Murphy (1983) in New York and Kansas. His lowest recorded nest was 2 m high. Cancellieri and Murphy (2014) found nest heights in Oregon more in range with mine; their average nest height of 1.47m was split into 1.64m and 1.17m for successful and failed nests respectively.

Vegetation

As grassland birds selected their nest sites, they were selecting many facets of the habitat. Vegetation species, the coverage of different types of vegetation, the amount of concealment from the vegetation, the proximity to an edge of two cover types, and anthropogenic management units were incorporated in their nest microsite selection.

Coppedge (2010) noted that woody vegetation in forb-dominated landscapes may increase red-winged blackbird survival and nests he monitored were common in emergent woody vegetation. Fletcher and Koford (2002) found wetland cover as

positively associated with red-winged blackbird abundance. At Closson, red-winged blackbirds selected woody vegetation on occasion, enough that nest sites had significantly more woody vegetation than random sites, but most selected tall goldenrod and parsnip or the post-burn growth of rosinweed and bergamot. There was not any emergent woody vegetation associated with the Closson wetland, but nests could have been hidden in the emergent non-woody vegetation that I did not search. Fletcher & Koford (2002) found red-winged blackbird abundance responded negatively to shrub cover. This species was by far the most abundant in all of my study sites, and all had either forest or shrub/tree populations within or surrounding the prairies, so other site characteristics may be more important for determining abundance on my study sites. Churchwell et al. (2008) found that dead vegetation cover was negatively associated with abundance, but blackbirds responded positively to vertical density and forb cover. This was supported by Conover et al. (2011) as they found that dead vegetation from the previous year was important for birds. Lapointe et al. (2003) noted that red-winged blackbirds responded positively to nest sites in areas with increased dead vegetation cover and increased visual obstruction. Increases in dead vegetation cover and dead vegetation height in my study was associated with increased survival probability, and both were higher in cover and height respectively, at successful nests, despite non-significant differences. My nests sites did have significantly higher visual obstruction and higher dead vegetation height than random sites. Contrary to Lapointe et al. (2003), nests had slightly less dead vegetation than random points.

Kobal et al. (1999) reported red-winged blackbird nests were in significantly taller grass and forbs than other species in their Illinois bird community, and microsites had

significantly higher visual obstruction. In my study, nest substrate height and live vegetation height carried about 1% increases in survival probability for a 1 cm height increase, but for each decameter increase in visual obstruction, survival decreased by 4.2%. Shew et al. (2019) found increased red-winged blackbird survival with higher visual obstruction. I found no difference between visual obstruction measurements at successful and failed blackbird nests. Above ground nests in their study showed increased survival with decreased forb cover. Forb cover was almost identical at nests of both fates that I monitored, suggesting survival in my study was not related to forb cover. Warren and Anderson (2005) found taller vegetation at successful red-winged blackbird nests in West Virginia. Like Warren and Anderson (2005), I found significantly more woody vegetation, and higher vegetation height at nests sites, and slightly more litter depth at random sites, but the difference was not significant. Conover et al. (2011) noted dead vegetation and vegetation height were important for red-winged blackbirds, which included survival decreasing with a decrease in dead vegetation cover (Conover et al. 2011). My regression showed a slight 0.93% increase in survival with every centimeter increase in dead vegetation height, and dead vegetation cover was positively associated with survival. Conover et al. (2011) found red-winged blackbird concealment from above at only 21-41%, much lower than the 72.64% in my study.

Red-winged blackbird and dickcissel nest heights were similar in my study, and Patterson & Best (1996) recorded similar grass and forb cover at both species' nests. Both used similar amounts of grass (RWBL = 26.76, DICK = 30.56), while I found far more forb cover was used at red-winged blackbird nests (66.25) than dickcissel (32.11). Conover et al. (2011) found higher vertical cover at red-winged blackbird nests compared

to dickcissels. In my study, both species had similar visual obstruction and live vegetation height, although slightly taller at blackbird nests. Fletcher and Koford (2002) for a negative relationship between wetland cover and dickcissel abundance. Of the three IDNR study sites, Closson supported the most dickcissel nests, which also had the highest amount of wetland cover. The square shape of the property may have been more attractive than the less uniform borders of Hindsboro and Burrus.

Conover et al. (2011) found that dickcissels selected dense standing live and dead vegetation associated with filter strips. Patterson & Best (1996) recorded increased dickcissel abundance in areas with increased vegetation height, and an increase in forb cover. My dickcissel nest sites had diverse vegetation characteristics, as forbs and grass averaged a cover of 30.5% and 32% respectively, dead vegetation was 21.5%, and woody vegetation dominated at 65.6%. This was coupled with high vegetation height, both live and dead, and an average visual obstruction of just over 6 dm. Conkling et al. (2015) recorded average visual obstruction of 43 cm for Mississippi dickcissel, not far from the average I recorded. Conover et al. (2011) found increased survival with nest height and lower survival with increased grass cover and vegetation density. Frey et al. (2008) found that vegetation obstruction was an important factor for dickcissels nesting in Oklahoma, and dickcissels were selecting forb patches for nest sites. Winter et al. (2000) found dickcissel success increased with increased vegetation height and vegetation density. Walk et al. (2004) noted no differences in visual obstruction, or grass and forb cover at dickcissel nests of either fate or at random sites. Logistic regression of dickcissel nests in my study showed an increase in survival with nest height (2.31%) and substrate height (1.4%), and an 8.26% increase with every 1 dm increase in visual

obstruction. Grass cover at my dickcissel nests carried a slight negative trend of less than 1% for a 1% increase in cover, which may be significant biologically and there was slightly more grass cover at failed nests. Forb cover was also higher at failed nests, but not near a significant difference. I did find significant differences for grass and forb cover between nest sites and random sites, indicating this species selected areas with increased woody vegetation cover which may have out-competed grass and forbs.

Winter et al. (2000) determined increased dickcissel nest success with increased litter depth, litter layer cover, and overall cover at the nest site, and reduced forbs and bare ground. Litter cover at my nest sites was slightly higher at failed nests, and litter depth was over 0.5 cm thicker at successful nests, although not significant. I found that nest sites had significantly taller live vegetation and dead vegetation heights, and visual obstruction measurements of just over 60 cm was higher than the 45 cm average at random sites. Fletcher & Koford (2002) found dickcissel populations responded positively to litter depth and forb cover, and negatively to vertical density. Kobal et al. (1999) found dickcissels had the highest bare ground value of around 25% and grass cover was lowest at 32%, and forb cover was significantly higher than other grassland birds at almost 70%. I recorded bare ground at dickcissel nests as the lowest of the four most detected nests (11%) and forb cover was 32.11%.

Concealment recorded at dickcissel nests by Lituma et al. (2012) was higher than mine, as their nests were 81-85% concealed. Conover et al. (2011) found overhead dickcissel concealment between 50-80%, and Conkling et al. (2015) found no significant differences between concealment and success. My nests were 78.5% from above and 69.4% from below, but my coarse categorization of 25% intervals may have limited more

precise concealment values. My dickcissel nests showed a very slight increase of survival with a 1% increase in concealment from above, and an almost 2% increase with increased concealment from below.

Frey et al. (2008) noted that increased litter cover increased survival. Since I used both visual and actual cover, I did find some differences with effects on survival. Red-winged blackbird survival decreased by 1.14% with each percent increase of actual litter cover. Dickcissel survival probability decreased 5.06% with visible litter, but decreased to just -0.55% with actual litter cover. Goldfinch survival increased 5% with visible litter and only .12% with actual, while field sparrow dropped from -3.3% to -4.04% from visible to actual.

All American goldfinch nests I discovered were built in woody vegetation. Kiviat (1996) compiled 5991 records of American goldfinch nest substrate from literature, and only 11.6% were built in herbaceous vegetation, further confirming that this species selects woody vegetation. The average height of nests found by Kiviat (1996) was 140cm, well below my original height average of 235cm. More comparable is my subset of lowered nests, which were manipulated to an average height of 133cm. Peak (2003) reported successful nests averaged 175 cm tall, and failed nests 168 cm. While I also saw successful nests higher on average, these heights were lower for each category (166 cm & 151.8 cm).

Fletcher & Koford (2002) found goldfinches were more abundant in prairies than in restored grasslands in Iowa, and they responded negatively to litter, vertical density, and slightly negatively with grass cover, but positively to forb cover, dead vegetation, and overall cover. Along with field and song sparrows, goldfinches had increased

abundance with higher grassland cover (Horn et al. 2002). Middleton (1979) noted the flexibility of American goldfinches to nest in different habitats, as they were found in cities, natural tree habitat, and nurseries. Goldfinches in my study sites were abundant no matter the cover type, and nesting substrate seemed to be the limiting factor. At nest sites, litter cover averaged 16%; this lack of available litter cover could be important, as Fletcher & Koford (2002) reported. Visual obstruction measurements at the nest was over 10cm higher than random points, which may refute their findings, although I did not focus on abundance. Grass cover was visibly very low (6%), but actually covered 26.5% of the Daubenmire area on average. Visible dead vegetation was slightly higher than grass using both measurements. If American goldfinches select nest sites based on visible amounts of cover, the low amounts would echo Fletcher & Koford's results; an application of using both types of cover measurements to determine these differences.

American goldfinch control nests in my study did not differ significantly by fate for concealment either from above or below. Control successful nests were significantly higher than failed nests, suggesting nest height was important for this group, and failed nests were more concealed, a potential trade-off of nest placement and the amount of directional cover from the substrate. Kleinhenz (1984) noted that successful American goldfinch nests had more concealment from above. My lowered group saw significant increases in concealment from above and a significant decrease in concealment from below. Raised nests had significantly less cover from above, and increased concealment from below that approached significance. Peak (2003) saw a reduction in concealment as vegetation was experimentally removed at goldfinch nests. She reported ground concealment around 67% and above concealment of 70-80%. My 55 nests had an

average below concealment of 68%, and from above it was 53.5%. My below concealment falls within Peak's range, while the upper end of my above concealment approaches hers, with my coarse cover categories. She could not link concealment to predation as DSR did not significantly differ and suggested that predation could be driven by predator abundance. I did have some differences in survival with changes in concealment, but they were not significantly diferent.

My overall nest success was high for American goldfinches, but was within the range of the limited research available. McCoy et al. (1999) found survival of 66.5% for 24 nests. Middleton (1977, 1979) recorded between 34%-79% survival, and Peak (2003) recorded 30% survival of a subset of nests with manipulated concealment. Nest success was high in both manipulated groups, although fewer losses occurred at raised nests, suggesting either the original height or higher manipulated height positively affected survival. Logistic regression showed little change for raised nests, as both had increases of survival of about 2.5% per 1 cm increase in nest height. Lowered nests began with a 1.3% decrease in survival, and became more negative to -2.2% with a 1 cm increase in nest height, indicating the new, lower nest height may have been advantageous for the group. Neither original nor manipulated concealment in my study resulted in a survival probability increase or decrease of more than 1%/cm increase, but biological significance could still be possible.

As seen with my goldfinch manipulation, there was usually a trade off in concealment from above or below as nest height changed. Nests that were lowered suffered more loss than raised nests, and lowered nests had more concealment from above and less from below. The significant changes in concealment after the

manipulation may have been biologically important for nest success, even without statistically significant differences. Since nest height and concealment were the only characteristics changing, it could be possible that other factors were also interacting with the changes to affect nest success.

Vickery et al. (1994) found field sparrows were associated with high shrub cover, and low bare ground. Kobal et al. (1999) associated field sparrows with trees and shrubs, which was not as supported as I expected with my nesting substrate results. Many nests were found surrounded by shrub cover, but others were not. There was more bare ground at random locations, but the difference was not significant with my 19 nests. However, woody vegetation cover was significantly higher at nest sites than random sites. Woody vegetation cover did not differ between successful and failed field sparrow nests and had a slightly negative relationship to survival. My results showed a non-significant 2% survival increase with above cover and -2% with increased below nest cover. Furthermore, a 1 cm increase in nest height resulted in an almost 7% decrease in nest success probability, showing a non-significant tendency to nest low in vegetation with more concealment from above.

Patterson & Best (1996) found higher common yellowthroat abundance with increased forb cover and were rarely seen in grass. My limited sample size showed higher grass than forb cover at nests, although these are averages. Vickery et al. (1994) found common yellowthroat abundance increased with smaller patch size and increased tall shrubs and trees. All 12 yellowthroat nests in my study were found near edges, or in corners of large parcels, and while only one nest was in woody vegetation, four (25%)

had some shrub cover within the Daubenmire frame. While shrubs were rarely used by yellowthroats, their placement near edges meant their nests were closer to shrubby areas.

Dead vegetation affected common yellowthroat fledglings for Murray & Best (2014) as increased dead vegetation at yellowthroat nests resulted in increased fledglings. More than half of their nests were in clumps of standing dead switchgrass. Nest sites in their study had more visual obstruction, forbs, dead vegetation, litter depth, live grass and woody vegetation than random sites. I found more dead vegetation cover at failed yellowthroat nests, and my nest sites had slightly more visual obstruction, slightly more grass, fewer forbs, more woody vegetation, more dead vegetation, and less litter depth than random sites. Half of my nests used dead vegetation either for primary or secondary nest attachment, which supported Murray & Best (2014). Thieme et al. (2015) found that common yellowthroat abundance increased with an increase in visual obstruction, and I noticed successful nests had over 1 dm higher visual obstruction than failed nests, and values at nest sites and random sites were very similar.

Mourning doves can nest in woody vegetation, and Armbruster (1994) recorded many losses due to windstorms, and none from predation. Ground nesting doves may have an advantage being protected by the surrounding vegetation during storm events. All three of my nests fledged, which may be due to increased vegetation concealment.

Compared to field sparrows and yellowthroats which nest in the same vegetation and height range as song sparrows, field sparrows had higher above concealment and lower below concealment at successful nests, which was the opposite for yellowthroats. Song sparrows monitored by Zuckerberg & Vickery (2006) responded positively to 0-50 cm grass height and shrub availability and abundance decreased with increased litter

depth. Chase (2002) noted song sparrows chose shrub areas for nests, but this had no bearing on nest success. Girard et al. (2012) found song sparrows foraged often in hedgerows, despite low shrub cover immediately surrounding nest sites, and hedgerow surrounding the nest site. Both of my nests were near either individual shrubs or a border buffer but were not surrounded by shrub cover. Saunders et al. (2003) found song sparrow nests in *Rubus* species and rose bushes. Closson had no sizeable Rubus or *Rosa multiflora* stands, while Hindsboro had some, and Burrus had large stands. As I would slowly work through them, I would notice buntings, sparrows, and yellowthroats flushing, but was unable to find nests due to the thickness and thorns. Two dickcissel, two field sparrows, an indigo bunting and an eastern towhee nested in either rose or berry bushes, with no indication of survival advantage. Murphy (1983) recorded eastern kingbird nests in mulberry, which coincided with both of my monitored nests.

Walker et al. (2008) found most mallard nests in grasslands, with an average visual obstruction of 3.18 dm and an average of 376 m from a water body. The mallard nest I monitored was about 300 m from the closest shore of the water body at Closson, and the Robel pole reading of 7 dm was much higher. Of the mallard nests found by Koford et al. (2016), more than 1/3 were found in grasslands and Artmann et al. (2001) noted mallards nested in higher density in grasslands when compared to croplands in North Dakota. The study stressed the importance of wet areas associated with grasslands, which Closson offered.

Henslow's sparrow relied on tall grass and deep litter layer for nests monitored by Kobal et al. (1999). The nest I monitored had only 2.25cm of litter depth, live vegetation height was 54 cm, and between 26-50% of the actual coverage was grass. They found

that Henslow's sparrows needed dense forb cover, standing dead vegetation, but no woody vegetation, and common yellowthroat abundance increased with increased medium shrub density. Forb coverage at the Henslow's sparrow nest was low, and visual obstruction averaged 45 cm. Vickery et al. (1994) found that eastern meadowlarks were associated with higher amounts of low shrubs, increased grass cover, and low levels of tall shrubs. The meadowlark nest at Closson was in the grassy southeast quadrant, with few shrubs. Zuckerberg & Vickery (2006) associated eastern towhee with increased litter layer and shrubs, and the species decreased with more low grass cover. Grass was not abundant at my two towhee nests, although litter cover was high.

Potter et al. (2011) studied bobwhites in Iowa and found increased nest success with as much as twice the forb cover as failed nests, suggesting increased cover, and a visual obstruction of 50-65 cm. Blank (2013) found higher bobwhite abundance in Maryland with increased CRP land, and attributed abundance to the increase in herbaceous vegetation within the CRP. Compared to random sites, Fogarty et al. (2017) found slightly more grass cover and significantly more concealment from above for meadowlark, bobwhite and grasshopper sparrow nests. My single bobwhite nests was completely concealed from above, and the nest site had more grass cover (Perceived = 37.5 vs. 2.5, actual = 37.5 vs. 15). Forb cover measured 15%, meaning 5-25% of the microsite was forb cover. West et al. (2016) found bobwhites may select increased litter depth, and litter cover percentage. Litter cover was in the 75-95% range in my study, but litter depth was only 1 cm deep.

The vegetation needs of some generalist birds have been noted in different management practices and land cover types. Merrill et al. (2016) determined that robins

favored more developed landscapes than thrashers in Illinois, but both selected similar amounts of shrubland. They also saw thrashers nesting in more dense vegetation, which may have decreased predation during the study. Closson was the only site with monitored nests of both species, and all nested in woody vegetation. Development wise, only sparse houses and silos were scattered in the landscape. Thrashers studied by Vickery et al. (1994) decreased in abundance with increasing grassland size and increased with tree abundance. They noted that as patch size increased, shrub density became sparse. I only found thrashers and their nests in areas with ample woody vegetation, which supports their findings.

I noted a 1.5 cm increase in litter depth after the southeast portion of Closson was mowed. Zuckerberg & Vickery (2006) noted an increase in litter depth as well. The only meadowlark nest in my study was mowed over, which is a reminder of potential ecological traps in the area. In Illinois, Kershner & Bollinger (1996) noted that increasing mowing decreased nest success, something I saw firsthand with the eastern meadowlark nest, and potentially more nests at that time. As Battin (2004) described, mowing can act as a trap because birds see favorable nesting cover, but are unaware of the plans of managers. The mowing should have occurred much later to ensure all nesting birds had a chance to fledge. Patterson and Best (1996) advocated for delaying mowing until after July.

Zuckerberg & Vickery (2006) found eastern towhee were attracted to burned areas, along with yellowthroats, and yellowthroats avoided shrubland that had been previously mowed, coupled with increased litter depth, , which I can support with my towhee nests in areas either in or close to the burned areas at Burrus and Closson.

Davis et al. (2000) found higher bird abundance in Minnesota savannah in burned plots. The post-burn transition may have reduced tree dependent species in their study, since trees were affected by fires, but the increase in new standing dead trees was also a benefit. They found many shrub nesting species that responded positively to burns, including American goldfinch, brown thrasher, and field sparrow. Since two Dickcissel nests were found in 2016 at Burrus, while never even hearing or seeing an individual in 2015, there should be consideration that the burn cycle may have attracted passing individuals to the site. It is possible that the burns attracted increased numbers of goldfinches, although I did not notice this through my observations.

Shochat et al. (2005) suggested that burning was responsible for decreased nest survival in Oklahoma. The burning of Closson, especially the northwest portion attracted many red-winged blackbirds. While these areas were small, 38 nests were discovered in this quadrant and 19 survived. More information would be needed to suggest this burn negatively affected red-wing blackbird production, as it could lead to an ecological trap. The most striking difference I noticed between seasons was the response to the burns at Closson. The early season burns created rapid new growth that was highly selected by the red-winged blackbirds. This replacement of vegetation structure should either be replicated with different plant communities or replicated over multiple years to see if this increase in nests was a one-time response or would be a repeated response. A lack of management will also affect the avian community. Cox et al. (2014) found conservation practices can increase abundance of dickcissel, yellowthroat, and grasshopper sparrow, while leaving grasslands unmanaged may benefit American robin, common grackle, and cowbirds.

Predators

I was unable to record verified nest predation with my cameras, because there were too many nests for three cameras to monitor, and the probability of a nest with a camera becoming predated was very low. Two nests failed with cameras, and circumstantial evidence may support white-tailed deer predation at a field sparrow nest (Figure 37). An indigo bunting nest at Closson captured an overexposed picture a day or two before a nest check that confirmed nest failure, but could not prove I captured a predation event.

Figure 37. A nocturnal white-tailed deer potentially predating a field sparrow nest, located in a forb patch

At night, when mesopredators are considered most active, the vegetation around a nest sometimes overexposed the camera's flash. The challenge was finding a distance that did not make the nest more detectible and did not disturb the adults, but also close enough to capture clear pictures. This became apparent when a yellowthroat pair mobbed

the camera, which made me more aware of the proximity of a camera to a nest. Unfortunately, with most nests being near the ground with few sturdy plants, the cameras were very close to the ground and obstruction by vegetation was usually an issue. That was why I moved cameras rather frequently, so I had many different perspectives even though the chance of capturing a predation event was low. Even with goldfinches it was hard to find camera placement, due to the spatial placement of nesting trees/shrubs and the varied heights of the nests. I only had one goldfinch nest monitored for this reason and it was more than 5 m from the nest.

The detection of raccoons, coyote and opossum and their associated biological indicators confirmed that possible mammalian nest predators were present on the properties, although there were no confirmed pictures at any nests of these animals. Small mammals were occasionally seen seeking refuge as I walked. Great horned owls were seen at all three IDNR properties, and barred owls were heard at Burrus. American kestrels were occasionally seen, including a fledgling at Burrus, confirming nesting at the site. Murphy (1983) recorded American kestrel predation on monitored nests. No shrikes were detected, and cowbirds, crows and some blue jays were present at all sites. Snakes were also common at all sites, the two species I saw were western fox snake (*Elaphe vulpina*) and *Thamnophis spp*.

The use of a mowed edge at Closson by coyote, opossum and raccoon may support the notion that nesting close to edges could lead to increased predation. Stanley (2010) found increased small mammal activity along edges. Winter et al. (2000) associated significant movement of predators within the first 50 m of a forest-grassland edge. They documented opossum, raccoon, fox, skunk, snakes, and squirrels depredating

nests. Ribic et al. (2012) found that predators associated with woodlands were detected up to 118 m into grassland fields. Since my study sites were not overly large, that distance easily puts more nests in harm's way due to a lack of interior habitat. Renfrew et al. (2005) and Renfrew and Ribic (2003) recorded raccoon, opossum, snake, ground squirrel, and cowbird predation. While 90% of edge species predated along wooded edges, some went as far as 200 m away from wooded edges (Renfrew & Ribic 2003). This presents additional confirmation that edge species do not only rely on edges for habitat. The suite of predators in the east-central Illinois region provided predation pressure on the entire grassland bird community at my study sites, as only 3-4 nests failed for reasons other than predation.

An American goldfinch nest I monitored failed with egg shells and rodent feces present in the cup, so rodent predation was likely at the study sites. This was also recorded by Davison & Bollinger (2000). Cox et al. (2012) captured mice predating indigo bunting nests in Missouri. Buntings were also preyed on by wild turkey in the study. Burrus was the only property where I saw and heard wild turkey and I do not expect them to be a major nest predator. Winter et al. (2000) used artificial nests to show decreased nest survival within 30 m of forest edges, with mesocarnivores predating many nests. I did not notice any differences in survival depending on where nests were placed. However, Robel et al. (2003) noted that artificial nests had higher survival, possibly due to the increased activity at real nests and the development of nestlings.

A fox snake I saw eating a fledgling dickcissel at Closson (Figure 38) had been recorded in other studies on dickcissel (Klug et al. 2010). Wells et al. (2007) monitored dickcissel and meadowlarks in Missouri and found that almost half of fledgling

dickcissels died and 28% of meadowlarks died, many suffering mortality within the first week post-fledging. Snakes were a common predator of dickcissels, along with mammals and raptors. Ribic et al. (2019) found that 78% of fledglings in their grassland fledgling study in Alberta, Canada and Wisconsin were terrestrial upon fledging, while being able to use their wings. They also found that fledglings will come back to the nest after the initial fledge event, showing some overlap between stages. This would make fledglings an easier target for snakes, especially if they came back to nests that they already knew were active.

Figure 38. Western fox snake eating a newly fledged dickcissel.

Walk et al. (2004, 2010) and Thieme et al. (2015) recorded garter snake nest predation, a species that was encountered at all study sites. Cagle (2008) studied snakes in tallgrass prairie in northern Illinois, and the census recorded 78% garter snakes. It was

noted that the research pointed toward recent snake declines, and conserving snake populations is imperative and can be done by connecting fragmented patches and expanding current protected land. In Oklahoma, kingsnakes were captured on camera predating nests (Fogarty et al. 2017). Patrick & Gibbs (2009) found a positive relationship between garter snake abundance and distance from a forested edge in New York oldfields, which may be related to thermoregulation needs. I did not detect snakes close to forested edges, all were seen beyond about 10-15 m from the ecotone. Klug et al. (2010) also found that snakes were more abundant in areas with shrubs, and increased vegetative heterogeneity. Klug (2010) found that successful grassland bird nests were in tall vegetation made up of grass and forbs, while some snake species had an affinity to areas with tall woody vegetation, suggesting snakes were drawn to woody cover and could predate shrub/tree nesters more frequently. This was coupled with decreased shrub cover as predated nests had 62% more shrubs. Since shrubs are present in grasslands, and can draw snakes to them (Klug et al. 2010), they suggest less than 5% shrub cover within a grassland landscape. Shrubs were an integral nesting substrate on my site, independent of actual nest success. This can run parallel to dangers of field sparrow nesting, since Thieme et al. (2015) found structural complexity of grasslands was important for field sparrow site selection. Many shrub/tree nests that I monitored failed without much disturbance to the surrounding area or nest; snakes could have been responsible in those instances. Pietz & Granfors (2000) noted that nest condition was not always an accurate indicator as an aide for determining the fate of a nest or type of predator. It is important to diligently look for signs of nest success in the area if you suspect it, especially for fledglings. I believe my diligence of searching and surveying

the surrounding area gave me the best determination of whether a nest close to fledging actually succeeded

Lyons et al. (2015) found snake predation decreased in burned areas, which could be related to their concealment from predators. Predation was apparent even in the burned sections of Closson, and without media evidence I cannot rule out snake predation. The vegetation grew back quickly, so the avoidance of snakes in those areas may not have been prevalent for very long.

Shochat et al. (2005) recorded almost 80% of predation events in their Oklahoma study were from reptiles, but only 28% of those were snake. Turtles accounted for the remainder, especially box turtles. I would occasionally come across box turtles and red/yellow-eared sliders, but never saw one on a trail camera or close enough to a nest to suspect predation.

While I cannot confirm raccoon predation on any nests, other studies have used technology to capture predation events. Conover et al. (2011) recorded raccoon predation on camera. A comparison of field and forest predation of grassland birds in Missouri noted a 100-600% increase in snake predation in fields, compared to forests, while raccoon predation was higher in forests than fields (Thompson III & Burhans 2003). Newbury and Nelson (2007) did not find nest searching behavior of Illinois raccoons as they moved through grasslands and along edges. They noted the underutilization of grasslands compared to availability, and that foraging occurred in forests and in riparian or wetland areas. Ribic et al. (2012) found that raccoons most commonly traveled through areas with low vegetation height, and avoided more complex CRP cover; they were more common in pastures, and twice as abundant along wooded edges compared to

non-wooded. If there was raccoon predation of my nests, I would also assume the nests were found opportunistically. Some patches within my sites were dense with either rubus or forbs, which may provide defense against raccoon movement and predation, and may be responsible for increased path wear at successful nests in my study. Taller and thicker vegetation was more likely to be broken by my paths, and these hard-to-navigate areas may be too dense for predators to navigate. This would mean a more agile predator may be responsible for nest loss, like small mammals or snakes. Vickery et al. (1992) noted skunks as the primary predator in Maine but did not notice nest searching behavior. Raccoons were captured on media, along with snakes, opossums, and coyote at northern bobwhite nests (Ellis-Felege et al. 2013) and Rader et al. (2007) added skunks, badgers, and ants, while also finding coyote and raccoon.

The 13 lined ground squirrel had been noted as a grassland bird predator (Dion et al. 2000; Klug et al. 2010; Ribic et al. 2012; Stanley 2010). Near the town of Hindsboro I would occasionally see one individual, but none were recorded at my study sites, despite a nearby population. My potential documentation of white-tailed deer predation led to interesting literature reviews which documented deer predation events. Deer were abundant at all of my study properties, and were frequently seen during field work, and captured on cameras. White-tailed deer had been recorded predating northern bobwhite nests (Ellis-Felege et al. 2013), and grassland bird nests in North Dakota (Pietz and Granfors 2000), and Iowa (Lyons et al. 2015). Deer were the most commonly captured nest predator in a Pennsylvania grassland study (Murray 2015). If deer were predating nests, even if opportunistic events, areas with large populations may see increased predation from this normally vegetarian browser.

Murphy (1983) noted pressures of weather, fox squirrels and American kestrel predation on eastern kingbird survival. While fox squirrels were seen at all locations, I never saw one within the limits of the actual grasslands. They seemed to stay closer to the wooded areas and did not strike me as a threat to nest survival. Klug et al. (2009) found that increased development in the landscape led to more predators like ground squirrels and cowbirds, and predators were negatively associated with higher variation in forb density. Lyons et al. (2015) found fewer mammals as forb density increased. A study using relocated completed red-winged blackbird nests in North Dakota found raccoon, skunk, common grackle, and mink predation (Sawin et al. 2003). Common grackles were sometimes seen at Closson, including a fledgling. A dead mink was found at Douglas-Hart Nature Center.

The brown-headed cowbird can be a common sight around the country, especially in grasslands. They were detected in every property in my study and parasitize some species' nests. Middleton (1991) recorded some parasitism in American goldfinch nests, but no fledglings. All but one nest carried a cowbird chick beyond 4 days, making it to 12 days. It was believed that the granivorous diet was not enough nutrition for cowbird survival. Middleton (1977) found a 1 individual reduction of American goldfinch brood clutch size with cowbird involvement, with over half of nests being parasitized in the first two weeks in July. Brood reduction from cowbirds was also apparent with Oklahoma dickcissels (Jensen & Cully Jr. 2005). Cowbird density affected parasitism rates in their study, not vegetation characteristics or edge proximity. Peak (2003) recorded two American goldfinch abandonments due to cowbird parasitism in east-central Illinois. In California riparian areas, American goldfinch nests were parasitized between 16-32%

(Dybala et al. 2014). The same study found 3/12 nests parasitized in remnant riparian habitat, and 0/40 in restored habitat, and common yellowthroats were parasitized 61.5% and 40% of nests, with small sample sizes. Only 2 of the 12 nests in my study were parasitized, but the species was still a target. It was hard to determine cowbird activity with such low parasitism rates, but Herkert et al. (2003) found that brown-headed cowbird parasitism increased for eastern meadowlarks as area decreased. They also suggested that cowbird parasitism rates can be a function of local abundance, since other species in the study did not experience the same pressure as meadowlarks. A study at Prairie Ridge State Natural Area (Walk et al. 2010), south of Charleston, IL, recorded very low parasitism rates. It could be that low cowbird abundance in east-central Illinois was responsible for a lack of parasitism, rather than edge effect of nest site characteristics. The eastern meadowlark and dickcissel seem to have a level of egg rejection (Peer et al. 2000), but this could not be supported with my results. Jensen & Cully, Jr. (2005) found no cowbird egg ejection from eastern meadowlark or dickcissel. Field sparrows accepted all cowbird eggs as recorded by Peer et al. (2000). As only 3/19 nests were confirmed to have been parasitized and accepted by my monitored field sparrows, this cannot lend credence to the group's results. Cox et al. (2012) recorded cowbirds in 33% of indigo bunting nests. Middleton (1977) recorded some cowbird parasitism on goldfinches in Ontario, although none fledged due to the diet of the host. Cowbirds parasitized song sparrow nests with increased tree density within 10 m of nests (Saunders et al. 2007). Shew et al. (2019) recorded cowbirds in 7.4% of blackbird nests and 18.1% in dickcissel nests in Illinois, while Murray et al. (2014) recorded 17% rates on yellowthroats in Iowa. Lituma et al. (2012) recorded 3% parasitism for dickcissel, and

higher survival in exotic grass grasslands when compared to restored landscape in Texas. Cox et al. (2012) noted an inverse relationship between cowbird predation and forest cover, while this relationship was positive for rodents.

Edges & Field Size

Adams et al. (2013) found few red-winged blackbird and dickcissel nests in buffers adjacent to woods, suggesting predation as a deterrent. While most dickcissel nests I monitored were along the woody edge buffers, none were near wooded areas. Many red-winged blackbird nests were in buffers, but interior nests were also common. The lack of forest cover at Closson may not show forest avoidance, although neither species was found near forest edges at Burrus, where grassland cover was more fragmented and surrounded by forest. Bollinger & Gavin (2004) noted woodland edge avoidance by bobolink in New York and lower DSR within 50 m of this ecotone when compared to nests more than 100 m from the edge. Re-nesting attempts were also further from edges. Bollinger & Gavin (2004) found that despite avoiding roadside edges, this edge yielded high survival for bobolink. Schocat et al. (2005) found the same high success near roadsides. Road edges without some kind of buffer in between did not attract many nests in my study. Hindsboro had about 250 m of roadside edge, with one field sparrow nest about 70 m away, which survived. Douglas-Hart Nature Center had the same amount along the east border of the prairie. Most of Burrus was separated by roads, and since the parcels were mostly narrow, many nests were within 100 m. They were all in prairie cover, which may negate roadside effect. Approximately half of Closson's 3000 m perimeter was paved roads, however the buffer may have confounded any roadside effect. Only three nests were found on the grassy separation between the road

and woody buffer with one surviving. Some of my dickcissel nests were found in shrub/tall grass buffers that were only 10-15 m wide, and red-winged blackbirds did not seem to avoid buffers as long as shrubs were available for nesting. This was especially evident along the western buffer of the northwest quadrant at Closson.

Puckett et al. (2009) noted the importance of conserving within 20 m of field edges. Since many birds enter and exit from these edges, it becomes important habitat for shelter and safety. These buffers can also increase foraging success. The woody buffers were commonly selected as nesting locations with my study, which may be an extension of the edge, depending on whether the buffer would be included or not as another edge type. Walk et al. (2010) suggested that southern Illinois dickcissel and eastern meadowlark may avoid wooded-grassland edges when initiating nests, whereas field sparrow nests were mostly found near this edge type. They also found that meadowlarks and dickcissels did not avoid grassland-cropland edges, consistent with my detection of many nests along buffer edges adjacent to fields either with or without a road in-between. The size of fields made it difficult to see what species truly avoided or selected forest-grassland edge nesting habitat, but many field sparrow nests were close to this ecotone. Stanley's (2010) study using both natural and artificial nests in Colorado found no significant survival benefits for either edge or interior habitat. He also detected no vegetation measurement differences between the edge and interior. With my study sites, vegetation differences were not apparent with my biweekly vegetation surveys depending on location within the field. There was some variation, but the largest differences were in the actual edge buffers with the highest proportion of woody vegetation. Shew et al. (2019) found decreased dickcissel survival as nests were placed

further from a non-grassland edge. Winter et al. (2000) found dickcissel nest success and Henslow's sparrow density decreased as proximity from edge decreased. Nests within 50 m of the edge had lower success and higher parasitism. They found no edge avoidance for dickcissel, something I also found with nest placement. Conover et al. (2011) found lower dickcissel survival close to crop edges, while Conkling et al. (2015) found no apparent edge effect on dickcissel survival. Only a handful of dickcissel nests were adjacent to crop fields without paved roads separating fields at Closson and Hindsboro, and about half of them fledged.

Schwenk & Donovan (2011) found more grassland bird species with increasing distance from edges in Vermont. Birds like American goldfinches, American robins, common yellowthroat, and mourning dove were more abundant closer to edges, and showed slight decrease to forest cover. There were approximately 10 red-winged blackbird nests within 50 m of the wooded Closson patch, and the remaining majority were in the narrow areas of the northwest quadrant, which lends some support to edge nesting. Interior nests in the southwest alfalfa quadrant were exceptions, since the length of the quadrant was around 270 m north to south. This allowed for some interior space. All 12 yellowthroat nests were within 75 m of an edge, either mowed, road, or wooded. The American robin was in a group which increased in abundance closer to edges and with more roads (Schwenk & Donovan 2011). Robin nests were scattered along the southern and western edges at Closson near roads, and only one was in the center of the property, less than 50 m from the wooded area. Puckett et al. (2009) found that while robins were moving well into crop fields from wooded edges, they used the first 20 m from the edge more than expected. Only two of my 9 nests were more than 100 m from

crop edges, and one was near a wooded edge. It is possible that robins at Closson were foraging in the crop fields and they treated the buffers as protective edges.

Puckett et al. (2009) found that American goldfinches were common within 20m of Nebraska wood-crop edges, and that this buffer length is the functional edge from a forest edge. American goldfinches tended to nest along edges due to the availability of fragrant sumac and dogwood at Closson and Hindsboro. The buffers seemed to provide enough habitat for goldfinches, as few nests were not found along the edges. Exceptions were at Hindsboro where scattered trees like dogwood and a honeylocust patch attracted them, and at Burrus, where an ash stand and singular trees were selected. If the buffers did not exist, I would have expected nests only around the forested margins of the fields.

Cox et al. (2012) recorded an average bunting nest to be 52 m from edges. They determined that nesting near edges was a poor strategy for the species. Weldon & Haddad (2005) suggested the nesting strategy of indigo buntings could be an ecological trap, and more complex edge shapes could lead to increased nest failure from predation. The edges near my 4 bunting nests were more linear and did not mirror their findings of better success with straight edge patches. More nests would be required to see if Illinois buntings respond the same way as they did in South Carolina. Henningson and Best (2005) noted a non-significant tendency for indigo buntings being found near wooded edges in Iowa filter strips. I also noticed this trend with the few individuals I saw, and only one of four nests was not within a few meters of a wooded edge.

Due to the size of the study sites, what would be considered interior habitat was lacking. In some cases, 50 m was narrow enough to cover an edge-to-edge area. Larger plot sizes would create more interior habitat, which may lead to higher nesting success.

In rare cases, 75 m - 100 m edge effect was possible on the sites, where the property became wider. Species like common yellowthroat and field sparrows were close to field edges, usually within 75 m. While some were extremely close to the edges, others chose grass clumps and shrubs further from their expected edge locations. Seeing few within the more interior areas strengthens previous research on edge species, and the relative interior habitat within my study sites reinforces the benefits of larger protected area.

Size recommendations vary by study and species for grassland birds. Herkert et al. (2003) used data from Illinois and nearby tallgrass prairie states to infer a decrease in daily predation rates with increased grassland fragment size. Their scale of less than 100 ha showed 78-84% of nests failing due to predation. Despite my largest property being half this group's maximum size, predation was around 50% for my nests, with only a few due to anthropogenic loss. This is more in line with Herkert et al. (2003) range of 54-68% for fragments over 1000 ha. Davis et al. (2006) suggests property larger than 18 ha for a suite of grassland birds, Kobal et al. (1999) suggest greater than 16 ha for Henslow's sparrow in Illinois, while Vickery et al. (1994) reccommend 50-200 ha for increased diversity. There were no survival benefits associated with patch size for Davis et al. (2006). Horn et al. (2002) found dickcissel abundance decreased as grassland landscape increased, and field sparrow and goldfinch were less likely to be found as field size increased. Dickcissel nest success increased for Winter et al. (2000) with increased patch size. As patch size increased for Walk et al. (2010), meadowlark and dickcissel survival decreased. Shew et al. (2019) found decreased dickcissel survival as field size increased. Herkert et al. (2003) did not find significant edge effect on survival and suggested larger areas would increase survival.

Benson et al. (2013) used a meta-analysis to determine that most of the time, edge effect yields no significant results when related to survival.

Nest Height Manipulation

The American goldfinch height manipulation was the first of its kind that I could find based on literature searches. I have read projects focused on nest microsite vegetation manipulation by either removing or altering the site, but my approach seems novel by moving the nest on the originally selected vegetation to a new location. There were no abandonments associated with the manipulation, which may mean this method could be used going forward as a new way to study the nesting tendencies of other species. Since nest height can change due to weather and the growing season, this would add valuable information determining whether human-influenced height changes affect abandonment more than natural disturbance. Since there were associated changes in the concealment from vegetation, this could be incorporated to determine if nest height and concealment are significantly related. It could be that selection is based on nest height independent of concealment, or vice versa.

Goldfinches responded to my presence with mostly agnositic behavior, so working with another species may present different challenges in terms of nest defense and chances of abandonment. The reattachment material of zip ties was used because they were easily threaded through the delicate thistle or other seed aggregate that made up goldfinch nests and were easy to secure around the tree branches and trunk. Unlike string which has very little surface area and could cause pinch points and damage when the nest became heavy, the zip ties held very well and could withstand the added weight of growing nestlings and the aggregation of feces. String was also very hard to push

through the nest due to its penetration ability, and I did not care to "sew" the string with a needle or pointed object because that would have involved more time spent with a nest, and potential puncture damage to eggs or nestlings. If needed, I could tie multiple ties together for less natural nest placement positions and could create a base to support the bottom of the nest. Glue was another possibility but that would have required me standing at a nest bracing the structure and waiting for the glue to dry, or I would have needed to brace the nest and leave, which may have done more damage and led to the nest being spotted more easily by a predator. Duct tape was another possibility, but I did not want to work with a sticky object, which would have added time to the process. I did not want to cut pieces, not really knowing what size would be needed, and compensation cuts would have been time consuming.

Naturally, the nest did sag due to increased weight, but I did not notice any severe leaning or degradation with the manipulated nests when compared to the naturally placed ones. This also made for easy clean up once a nest met its fate, because a few scissor snips released the ties and I was ready for the nest site assessment. I could perform the entire process of nest removal and replacement in about five to seven minutes. This included finding a suitable replacement site on the same substrate at ideally the next highest or lowest branch where a goldfinch could build a nest. The idea was to create new zones of nest placement and possible new predation pressures without purposefully dropping a nest so far that predation was a lot more likely. That is why the next highest or lowest possible nest placement site was used, and why there was not a standard amount of distance that I used in either direction. To reduce bias further, it may have been appropriate to include a control group of nests that were removed and reattached at

the same nest height. Due to sample size restrictions, this might further decrease sub-groups, so I was comfortable with the three groupings with the control nests.

This could also be a way to better understand any nest predator preferences that may be limited in their access to nests at certain heights. There were decreases in survival probability post-manipulation for both groups, which could be an issue with more vulnerable species with lower abundance than American goldfinches. However, nests could only fail within the manipulation group post-manipulation; if a nest failed prior to manipulation it was placed in the control group as a subset without a mock manipulation. This means survival is automatically lower post-manipulation for manipulated nests.

This strategy may release certain species from some predators while exposing them to others in their new height placement. In this study, predation still occurred with taller placed nests, although more predation occurred at lower and control nests. However, control successful nests were significantly higher than failed nests. This practice should be tested with common species with little to no risk of declining populations and with different nest structures to see how attachment is accomplished, and how nest integrity progresses during the nestling's development. Adding an additional treatment to my methods may have helped to determine if the action of removing a nest and then fastening it at the same location would have any effect on survival. Predation occurred at all height ranges and was one reason why nests slated for manipulation could not be moved. A more even grouping of nests in each group may have led to better comparisons for survival. I believe the mock manipulation was a good way to standardize the groups, even if the control nests were not touched.

Parental investment at nests

Muchai & du Plessis (2005) found that more parental activity was seen during the nestling stage when compared to incubation. They found that in general, predation was not higher during one stage, although evidence suggested the incubation stage had a higher chance of predation. They also found that predation could increase with parental activity. In my study, DSR was lower during the incubation stage for most species. Yasukawa (2017) recorded higher DSR for red-winged blackbird nests that had both parents involved at the nest. Males who provided nest defense saw higher nest survival, and their attacks were positively associated with success. Merrill et al. (2016) found high nest defense on a 0 - 6 rating scale for brown thrashers, higher than American robins. My robins averaged 1.6 for anger, all assumed from females, and the three thrasher nests averaged 1.19. Merrill et al. (2016) noted an increase in thrasher aggressiveness as surrounding shrubland decreased. The shrubby buffer edges at Closson may have been why I recorded such low behavior, while they recorded a score of almost 4.

Kingbird aggression was twice as high for males in Oregon during the incubation and nestling stages (Redmond et al. 2009). Aggression increased with the age of nest contents, and it was suggested that the increase in nest contents' value was the reason for increased aggression. While their failed kingbird nests had slightly higher defense values, this was not significant. At my two kingbird nests, both adults were present on 11/13 checks, were not present for the remaining two checks, and they always exhibited the second highest aggressiveness. Ellis-Felege et al. (2013) found northern bobwhites were more defensive against smaller potential predators, and some adults were killed if they did not leave the nest and weigh their lives over the nests. My presence may be

associated with this inference, as sitting adults may have weighed their lives against defending the nest against a human, although of course I meant no harm.

Yasukawa (2016) determined that begging did not influence survival, and the increased nest visits during this stage did not affect survival. Nestling DSR for blackbirds in my study was almost 4% higher than in the incubation stage, showing a potential link of increased nest age and survival. Rastogi et al. (2006) found that food supplemented song sparrows saw less diurnal predation, since they spent more time on the nest. Anti-predator actions increased for adults that were food supplemented. There were fewer departures from the nest and foraging trips were shorter when the adults had supplemented food available. No differences were found during the nestling stage, as the needs of the nestlings resulted in more foraging trips; an hourly average of 13.5 departures/hr were recorded, even with supplementation. For my nests, I would expect more foraging behavior during the nestling stage, and like Rastogi et al. (2006) most species were found less on the nest during the nestling stage when compared to incubation. American robin and field sparrow were exceptions, but the number of nest checks for these species along with common yellowthroat were low.

Red-winged blackbirds were the only of the most sampled species where the male was more present than the female. The gap between male and female was closest for dickcissel, as females were near the nest more often by a 40% margin. Male goldfinches, field sparrows, yellowthroats and robins were either hardly or never present. It seems females are the first line of defense if a predator approaches, while red-winged blackbirds are near the nest more than females and ready to pursue. American robin females were on the nest over half the time, so males may be foraging for both themselves, females,

and nestlings. After 406 red-winged blackbird nest checks, females only flushed 50 times. Dickcissel and goldfinches were more commonly on the nest during incubation and the nestling stage, possibly due to males foraging for the nest. Red-winged blackbird females may be more responsible for their own food and feeding nestlings, which may be a reason for low nest-sitting occurrences

Future Considerations

The grassland biome continues to be one of great importance. Any research pertaining to survival of grassland bird communities will be important for tracking future trends, and will add to the current literature of what cover types grassland birds select for breeding. Nest height manipulation could be useful for species that nest in woody vegetation and experience high predation rates, as a way of determining more successful nesting heights. This could also be a way to better understand any nest predator preferences, who may be limited in their access to nests at certain heights, and their ability to detect a nests with vegetation blocking the nest. This manipulation strategy may release certain species from some predators while exposing them to others in their new height placement. This practice should be tested with common species with little to no risk of declining populations and with different nest structures to see how attachment is accomplished, and how nest integrity progresses during the nestling's development.

Conclusion

Any research pertaining to bird nest success in sensitive biomes may also lead to management that protects the entire ecosystem. Mammals, reptiles and amphibians, and insects were abundant, and they can respond positively to efforts of conservation and proper land use. My study sites provide resources for 170-200 bird species throughout

the year, so we cannot forget that breeding habitat for some species is also important at other times of the year.

Nest height for the grassland bird community is one factor that influences survival. The placement of the nest depends on the type and height of vegetation, which affects the amount of concealment surrounding a nest. Nest height manipulation can affect the concealment of nests and may affect survival. There are many vegetation characteristics surrounding a nest site, and differences can be determined between what specific species are selecting for when compared to the surrounding landscape. It is harder to determine significant differences that lead to increased nest success, but the biological importance should not be overlooked. Predation will always occur at some level, and the nesting strategies of grassland birds need continued research to determine the most beneficial vegetation and management to ensure their health in a sensitive biome.

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